

SOIL SURVEY OF

Pawnee County, Nebraska



United States Department of Agriculture
Soil Conservation Service
In cooperation with
University of Nebraska
Conservation and Survey Division

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1961 to 1968. Soil names and descriptions were approved in 1969. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1969. This survey was made cooperatively by the Soil Conservation Service and the University of Nebraska Conservation and Survey Division. It is part of the technical assistance furnished to the Nemaha Natural Resource District and the Lower Big Blue Natural Resource District.

Soil maps in this survey may be copied without permission, but any enlargement of these maps could cause misunderstanding of the detail of mapping and result in erroneous interpretations. Enlarged maps do not show small areas of contrasting soils that could have been shown at a larger mapping scale.

HOW TO USE THIS SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Pawnee County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the windbreak suitability group and range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suit-

ability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units, the range sites, and the windbreak suitability groups.

Foresters and others can refer to the section "Use of Soils for Woodland and Windbreaks," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of the Soils for Wildlife and Recreation."

Ranchers and others can find, under "Use of the Soils for Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about soil formation and classification in the section "Formation and Classification of Soils."

Newcomers in Pawnee County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "Environmental Factors Affecting Soil Use."

Cover: Terraces, grassed waterways, and windbreaks in an area of the Pawnee-Mayberry-Burchard association.

Contents

	Page		Page
How this survey was made	2	Range sites and condition classes ..	41
General soil map	3	Descriptions of range sites	42
1. Wymore association	3	Use of soils for woodland and wind-	
2. Pawnee-Mayberry-Burchard		breaks	45
association	3	Windbreak suitability groups ...	46
3. Kennebec-Judson-Wabash asso-		Use of the soils for wildlife and	
ciation	5	recreation	47
4. Benfield-Kipson-Sogn associa-		Engineering uses of the soils	48
tion	6	Engineering soil classification	
Descriptions of the soils	8	systems	49
Benfield series	8	Soil test data	50
Burchard series	10	Soil properties significant to	
Butler series	11	engineering	50
Colo series	11	Engineering interpretations of	
Crete series	12	soils	51
Judson series	13	Formation and classification of soils ..	64
Kennebec series	13	Factors of soil formation	65
Kipson series	15	Parent material	65
Malcolm series	16	Climate	66
Mayberry series	17	Plant and animal life	66
Morrill series	19	Relief	67
Pawnee series	20	Time	67
Rough broken and gullied land	22	Classification of soils	67
Shelby series	23	Physical and chemical analyses	68
Silty alluvial land	24	Environmental factors affecting the	
Sogn series	24	use of soils	68
Steinauer series	25	Relief	69
Wabash series	26	Physiography	69
Wet alluvial land	27	Drainage	69
Wymore series	27	Climate	69
Use and management of the soils	29	Water supply	71
Use of the soils for cropland	29	Transport facilities and markets ..	71
Capability grouping	30	Farming	71
Management of tame pasture ...	39	Literature cited	72
Predicted yields	40	Glossary	72
Use of the soils for range	40	Guide to mapping unitsFollowing	74
Management and improvement of			
range	40		

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SOIL SURVEY OF PAWNEE COUNTY, NEBRASKA

BY HOWARD E. SAUTTER, SOIL CONSERVATION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF NEBRASKA CONSERVATION AND SURVEY DIVISION

PAWNEE COUNTY is in the southeastern part of Nebraska. The state of Kansas is its south border (fig. 1). The county is a rectangular area of 277,120

percent is rangeland and pastureland, about 3 percent is woodland, and 4 percent is other farm land. The remaining 15 percent is nonfarm land.

The principal crops grown are grain sorghum, corn, wheat, alfalfa, hay, and soybeans. Minor crops are oats, clover, and orchard crops, mainly apples. Cattle, hogs, and chickens are raised on most farms, and sheep are raised on a few farms. A few horses are kept on ranches and diversified farms for work or pleasure.

The climate is continental, and the temperature and precipitation vary greatly from season to season and from day to day. The climate is suitable for growing common staple crops and grasses and for raising livestock.

Pawnee County is on a dissected glacial plain within the Great Plains physiographic province. The relief ranges from nearly level to very steep and consists of extensive uplands, a few stream terraces, and numerous continuous strips of narrow bottom lands. The largest valleys are those of the North Fork and South Fork of the Big Nemaha River, where the channels have been artificially straightened. Most of the county is a succession of rounded ridges, intervening hillsides, and entrenched drainageways. The drainage pattern is chiefly southeastward. The major streams are fed by many tributaries.

The major soil of the uplands formed in glacial till and loess. The minor soils formed in shale and limestone. Water erosion is the principal hazard. Conservation of water through prevention of runoff and maintenance of fertility are major concerns of management.

Soils in the valleys formed in alluvium and colluvium. Occasional flooding is the principal hazard. Maintaining fertility is an important concern of management on these soils.

Soils in Pawnee County are mainly silty and clayey. Very few of the soils are sandy. The soils range from deep to shallow, from well drained to very poorly drained, and from nearly level to very steep.

Much information has been gained about the different kinds of soil and their management since the early pioneers first used them. Improved methods of cultivation and grass management and new crops, grasses, and tree varieties have increased yields and stabilized

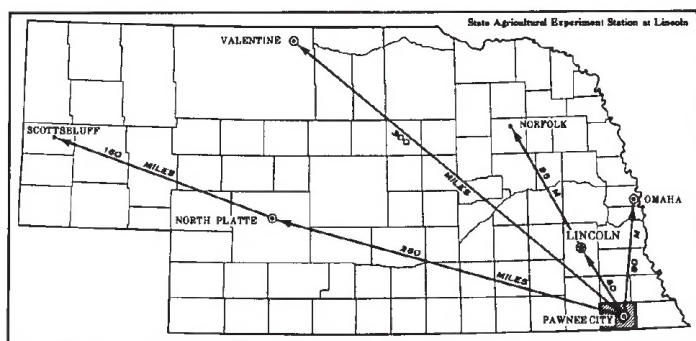


Figure 1.—Location of Pawnee County in Nebraska.

acres, measuring 24 miles from east to west and 18 miles from north to south.

In 1804, Lewis and Clark, of the U.S Army, discovered this part of the country in possession of the Pawnee Indians. The Kansas-Nebraska Bill opened the territory for settlement in 1854. The first settlers of European descent came from Ohio and settled the valley of the South Fork of the Big Nemaha River. They plowed the soil of the open prairie, and corn, wheat, potatoes, berries, fruits, and other garden crops were grown.

After the passage of the Homestead Act, the arrival of more permanent settlers increased farming in the county. New roads and railways opened towns for marketing. The acreage planted to corn and wheat increased, and cattle and hogs were raised and marketed.

In 1970, Pawnee County had a population of 4,274. Pawnee City is the county seat and largest town, having a population of 1,330. Most residents make their living by farming, and many others have vocations related to farming.

Most farms in Pawnee County are of the cash-grain or diversified grain-livestock type. According to the 1969 U.S. Census of Agriculture, about 58 percent of the total acreage of the county is cropland, about 20

farming. As farmers till the soil, manage the plants, and tend livestock, they gain more knowledge and experience. The demand for food and the new technology have made farming a major industry. The soils in Pawnee County have potential for farming development.

An older Survey of Pawnee County was published in 1924 (3).¹ The present survey was made to provide additional update information for advanced farming methods, engineering techniques, and soil classifications.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Pawnee County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and nature of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Burchard and Pawnee, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that effect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Pawnee clay loam, 3 to 9 percent slopes, eroded, is one of several phases within the Pawnee series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of

this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Pawnee County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Kipson-Sogn complex is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. Colo and Kennebec soils, occasionally flooded, is an example of an undifferentiated group in Pawnee County.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Wet alluvial land is a land type in this county.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this failure to the slow permeability of the soil or its high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential use.

¹ Italic numbers in parentheses refer to Literature Cited, p. 72.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Pawnee County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The terms for texture used in the title of the associations apply to the texture of the surface layer. For example, in the title of Kennebec-Judson-Wabash association, the words silty and clayey refer to the texture of the surface layer.

Soil association names and delineations on the general soil map may not fully agree with those of the general soil map in adjacent counties published at a different date. Differences on the maps are the result of improvements in the classification or refinements in soil series concepts. In addition, more precise maps are needed because the uses of the general soil map have expanded in recent years. The more modern maps meet this need.

The four soil associations in Pawnee County are each described in the following pages.

1. Wymore Association

Deep, nearly level to gently sloping, silty to clayey soils on loess-capped uplands

This soil association is on ridgetops in the loess-capped uplands (fig. 2). Most of the ridgetops are rounded. Most of this acreage is nearly level to gently sloping. Included in this association are the uppermost parts of a few natural drainageways. Some of the highest elevations in the county are in this association.

This soil association makes up about 15 percent of the county. About 90 percent of it is Wymore soils. The rest is Pawnee, Mayberry, Butler, Judson, and Kennebec soils.

Wymore soils, on the ridgetops, are deep and moderately well drained. They formed in loess. Typically, the surface layer is the black silty clay loam about 13 inches thick. The upper part of the subsoil is very dark brown silty clay; the middle part is dark grayish-brown and grayish-brown silty clay; the lower part is olive-gray silty clay loam. The underlying material is olive-gray and dark grayish-brown mottled silty clay loam.

Pawnee soils are on a few isolated ridgetops and on upper parts of hillsides near upland drainageways. In most places they are at lower elevations than Wymore soils. Butler soils are near the heads of upland drainageways. Kennebec soils are on the bottom lands of narrow upland drainageways. Mayberry soils are downslope from Pawnee soils on hillsides. Judson soils formed in colluvium on foot slopes.

Nearly all of this association is used for growing cultivated dryland crops. A few small tracts are planted to tame pasture grasses, such as brome grass, and a few areas are in native grass. The major crops are grain sorghum, corn, wheat, alfalfa, and clover.

The principal hazard on soils of this association is water erosion. Low fertility, low content of organic matter, and poor tilth are limitations of the severely eroded soils. Improvement and maintenance of fertility are needed on all the soils of the association. During periods of little rainfall, the soils are droughty.

Farms in this association are mainly of the cash-grain and combination grain-livestock types. In most places the supply of good water is limited but generally is adequate for domestic use.

This association contains a few farm ponds that are used as a source of water for livestock. Most roads are unpaved. They are well graded and follow section lines. A few roads are surfaced with crushed rock. Most of the cash grain and other produce is marketed in Pawnee City, in DuBois, or in Summerfield, Kansas.

2. Pawnee-Mayberry-Burchard Association

Deep, nearly level to moderately steep, loamy and clayey soils on glacial uplands

This soil association is on the tops and sides of upland ridges and on the dissected sides of upper valleys (fig. 3). These uplands are composed of material of glacial origin. Slopes range from nearly level to moderately steep. Included in this association are many narrow drainageways that extend into the uplands. Boulders, stones, gravel, and sand pockets are exposed at the surface in many places. In many areas the soils are severely eroded.

This soil association makes up about 64 percent of the county. About 42 percent of it is Pawnee soils, 14 percent is Mayberry soils, and 10 percent is Burchard soils. Minor soils and land types make up the other 34 percent. These are Rough broken and gullied land and Wymore, Shelby, Morrill, Steinauer, Malcolm, Judson, Kennebec, and Colo soil.

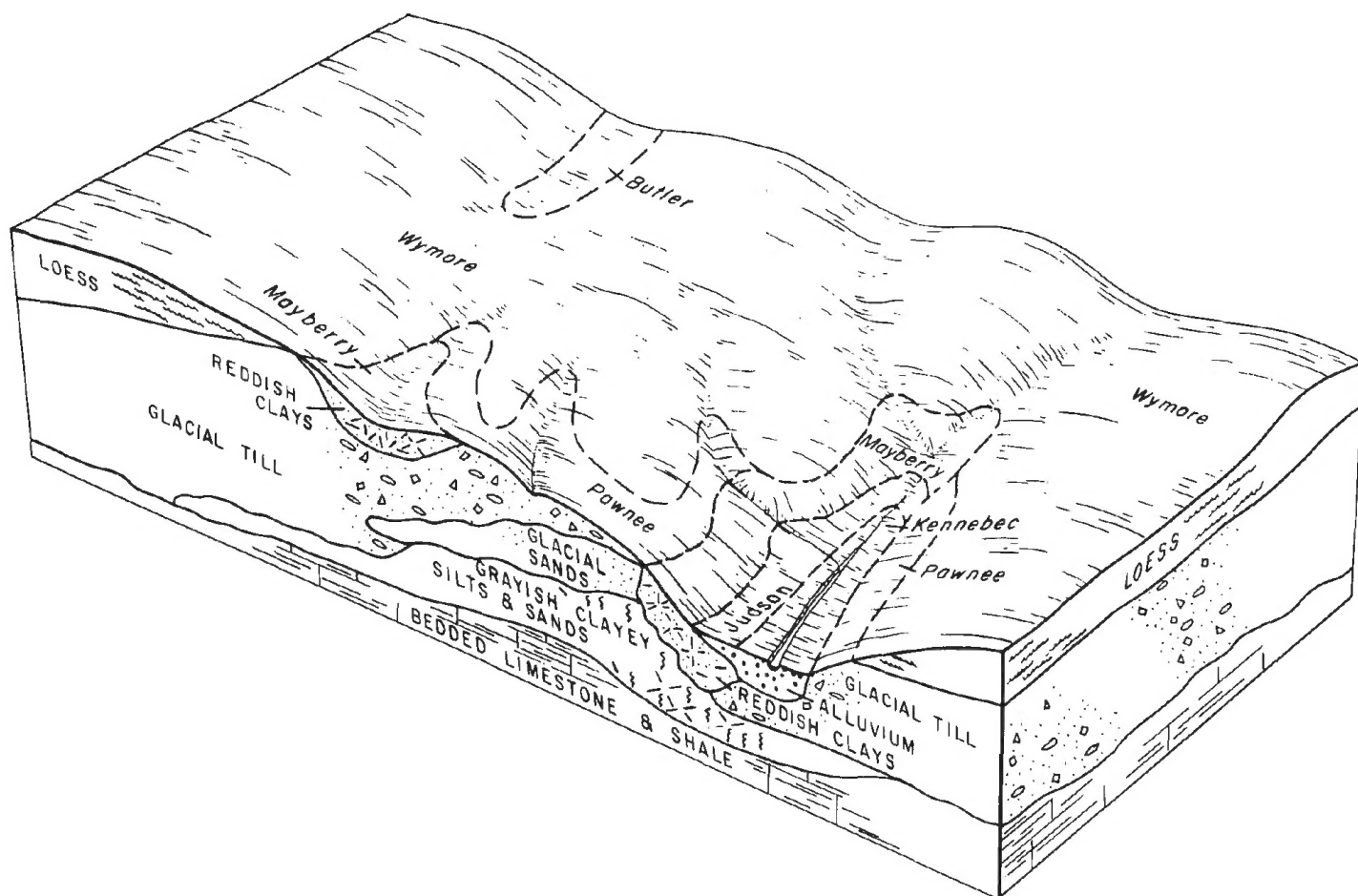


Figure 2.—Typical pattern of the soils in association 1.

Pawnee soils are deep and moderately well drained. They formed in glacial till. Typically, the surface layer is very dark brown loam and clay loam about 10 inches thick. The subsoil is dark-brown, dark yellowish-brown, olive-brown, and yellowish-brown clay. The underlying material is grayish-brown mottled clay loam.

Mayberry soils are deep and moderately well drained. They formed in weathered material reworked from glacial deposits. The subsoil is redder than that of the Pawnee soils. Typically the surface layer is black and very dark brown loam and clay loam. The subsoil is dark reddish-brown and reddish-brown clay.

Burchard soils are deep and well drained. They formed in glacial till. The subsoil is not so fine textured as that of Pawnee and Mayberry soils. Typically, the surface layer is very dark brown and very dark grayish-brown clay loam. The subsoil is mainly brown, olive-brown, and grayish-brown clay loam. The underlying material is light brownish-gray and light olive-brown mottled clay loam.

Wymore soils are on ridgetops at the highest elevations of the upland landscape. Steinauer soils are on knolls and on the sides of valleys. Shelby soils are on hillsides. Morrill soils are on the lower parts of the sides of valleys that border drainageways. Malcolm

soils are on sides of valleys along drainageways leading to the North Fork of the Big Nemaha River. They are below Pawnee and Mayberry soils on the landscape. Judson, Kennebec, and Colo soils are in valleys that are broad in places and narrow in places. Rough broken and gullied land occupies the steep and very steep banks and gullied channels of drainageways.

About 50 percent of this association is used for cultivated crops. The remainder is mainly hay, pasture, and range. The principal cultivated crops are corn, grain sorghum, wheat, alfalfa, and clover. These soils are also suitable for trees in windbreaks and for use as recreational areas.

Water erosion is the principal hazard on the soils of this association. Conserving surface water by intercepting the runoff is important. Other concerns of management are maintaining the high fertility and improving the content of organic matter. Flooding is a minor hazard in the upland drainageways. Areas that are in grass need grazing control and weed and brush control to insure vigorous growth of the grasses.

Farms in this association are mainly the combination grain-forage-livestock type. Cash-grain types are not common. In most places, the supply of good water from wells is limited, but the water is generally adequate for domestic use. A few springs are along the

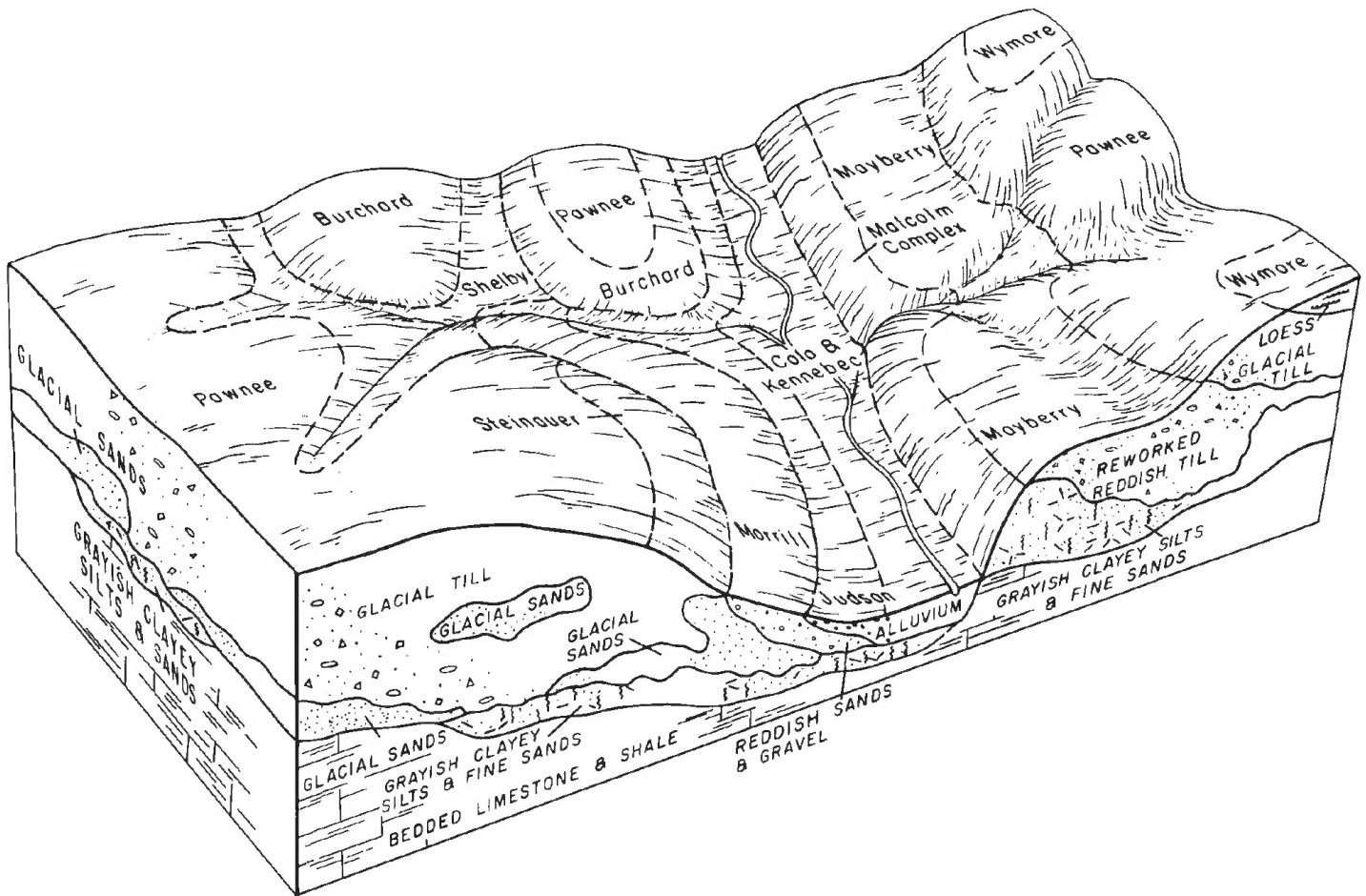


Figure 3.—Typical pattern of the soils in association 2.

drainageways. Surface water is collected in a few ponds as a source of water for livestock. Potential sites for dam construction are numerous.

Most roads are unpaved, but they are graded and maintained. A few arterial farm-to-market roads are surfaced with crushed rock. Nearly all the roads are on section lines. Most of the livestock are sold at auction in local sale rings or are trucked to larger terminals, such as St. Joseph, Missouri. Cash grain is marketed mostly at local elevators.

3. Kennebec-Judson-Wabash Association

Deep, nearly level to gently sloping, silty and clayey soils on bottom lands

This soil association is on footslopes, bottom lands, and stream terraces in the valleys of the North Fork and South Fork of the Big Nemaha River, Turkey Creek, and a few other smaller creeks of the county (fig. 4). The channels of the Big Nemaha River have been straightened. Slopes range from nearly level to gently sloping. The lowest elevations in the county are in this association.

This soil association makes up about 15 percent of the county. About 40 percent of it is Kennebec soils,

25 percent is Judson soils, and 17 percent is Wabash soils. Land types and minor soils make up the other 18 percent. These are Wet alluvial land and Silty alluvial land, and Colo and Crete soils.

Kennebec soils are deep and moderately well drained. They formed in silty and loamy alluvium. The surface layer is black silt loam about 30 inches thick. The transitional layer between the surface layer and the underlying material is 12 inches of very dark gray silt loam. Extending to a depth of 60 inches, the underlying material is very dark grayish-brown and dark grayish-brown silt loam and loam.

Judson soils are deep, well drained, and on footslopes. They formed in dark sediment washed from adjacent uplands. Typically, the surface layer is very dark brown and black silt loam and silty clay loam about 27 inches thick. The subsoil is very dark grayish-brown and dark-brown silty clay loam.

Wabash soils are deep and poorly drained. They formed in clayey alluvium. Typically, the surface layer is about 36 inches thick. The upper 13 inches is very dark brown and black silty clay loam. The lower 23 inches is black silty clay. The transitional layer between the surface layer and the underlying material is 16 inches of very dark gray and very dark grayish-

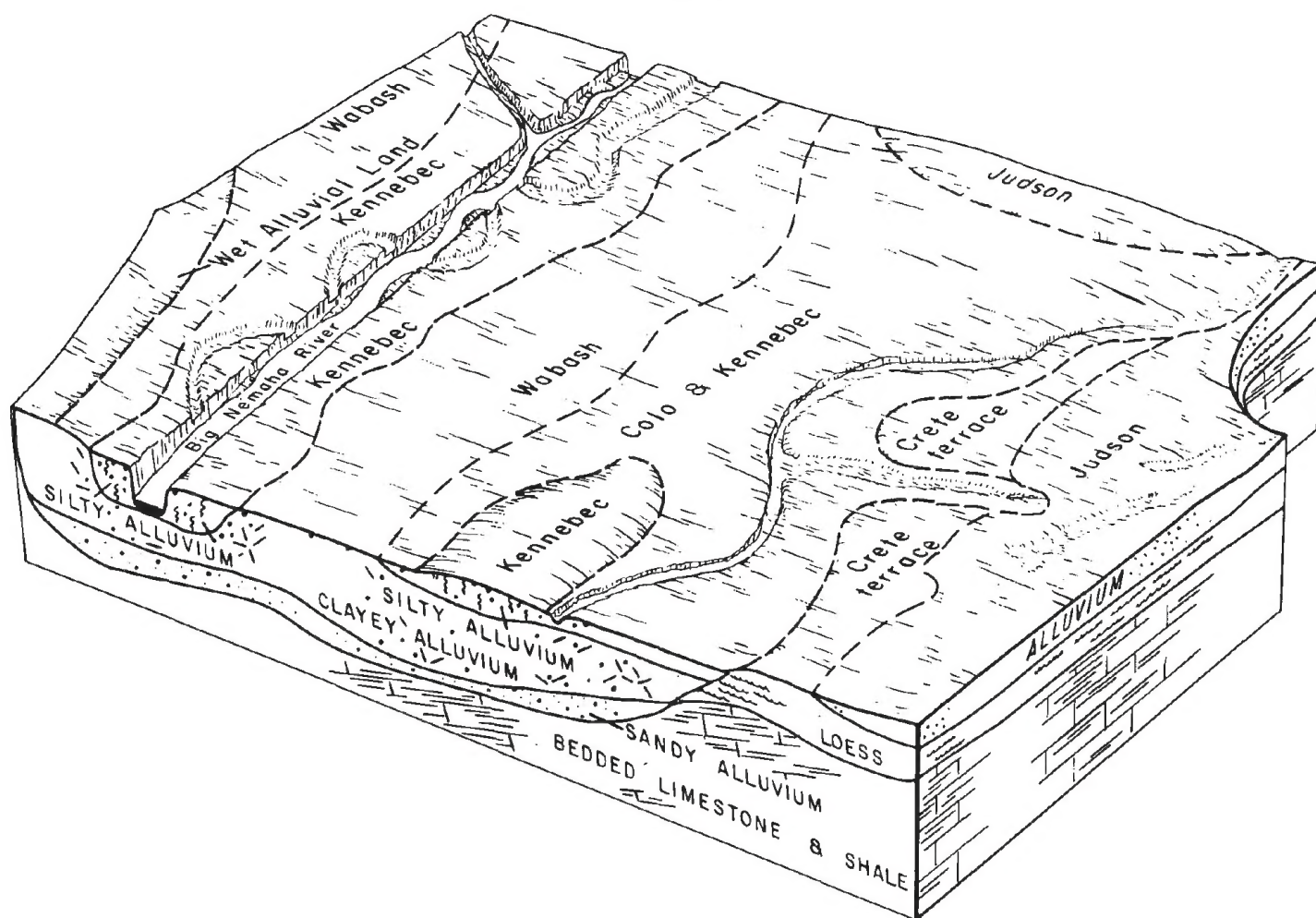


Figure 4.—Typical pattern of the soils in association 3.

brown silty clay. The underlying material is very dark grayish-brown silty clay.

Colo soils are on bottom lands at slightly lower elevations than the major soils. Crete soils are on a stream terrace. They are slightly above Colo soils and are below Judson soils on the landscape. Wet alluvial land includes seeped areas adjacent to uplands. Silty alluvial land is along meandering streams and creeks. It is subject to frequent flooding.

Most of the acreage of this association is cultivated. The principal crops are corn, grain sorghum, and wheat. About 15 percent of the acreage is used for pasture and hay.

The principal concerns of management on the soils of this association are maintaining the high fertility, high content of organic matter, and good tilth. Flooding is a hazard, and drainage is needed in some areas. Water erosion is ordinarily not a hazard, except on the gently sloping Judson soils.

Most farmers use these soils for cash grain. A few areas are in pasture or range and are used for grazing livestock, mainly cattle. The supply of good-quality water from wells is limited, but it is generally adequate for domestic use. Seepage areas provide sites for dugouts in a few range areas.

This association has only a few farmsteads. Most of the roads are on section lines and are unpaved. Many section lines, however, have no roads. Farm produce is marketed mainly in Pawnee City, Table Rock, and DuBois.

4. Benfield-Kipson-Sogn Association

Moderately deep and shallow, gently sloping to very steep, silty and clayey soils on shale and limestone uplands

This soil association is in irregular strips on the sides of the valleys of the North Fork and South Fork of the Big Nemaha River and Turkey Creek (fig. 5). Slopes range from gently sloping to very steep. Shale and limestone bedrock crops out on the steepest parts and on ledges. The area is dissected by numerous short intermittent drainageways that empty into the large stream valleys.

This soil association make up about 6 percent of the county. About 49 percent of it is Benfield soils, 36 percent is Kipson soils, and 7 percent is Sogn soils. The rest is minor soils. The minor soils in this association are Morrill, Judson, and Wymore.

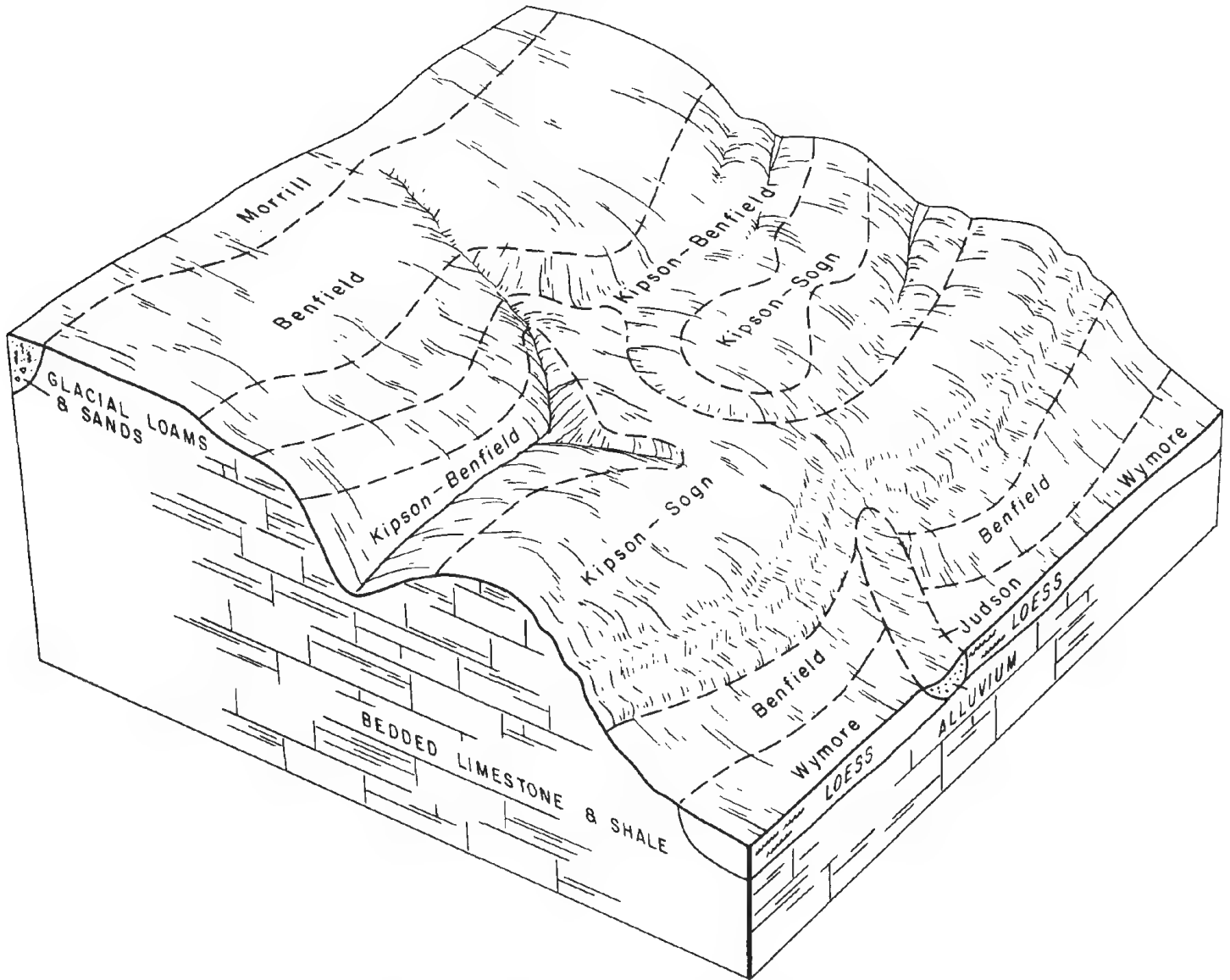


Figure 5.—Typical pattern of the soils in association 4.

Benfield soils are moderately deep over shale and are well drained. Typically, the surface layer is very dark brown silty clay loam about 14 inches thick. The upper 21 inches of the subsoil is dark-brown silty clay. The lower 5 inches is olive-gray heavy silty clay loam. At a depth of 40 inches is olive-gray, olive-brown, and brownish-yellow silty and clayey shale. Benfield soils are gently sloping to moderately sloping.

Kipson soils are shallow over shale and are somewhat excessively drained. Typically, the surface layer is very dark grayish-brown silty clay loam about 9 inches thick. The transitional layer between the surface layer and the underlying material is brown silty clay loam. At a depth of 17 inches is mixed pale-yellow and light olive-brown silty and clayey shale that contains many limestone fragments. Kipson soils are gently sloping to very steep.

Sogn soils are shallow over limestone and are excessively drained. Typically, the surface layer is very dark brown silty clay loam about 8 inches thick. Beneath this is hard limestone bedrock. Sogn soils are gently sloping to very steep.

Morrill soils are at higher elevations than Benfield soils. Judson soils are on foot slopes below the major soils. Wymore soils are mostly on the highest ridgetops above Benfield soils. In the southeastern part of the county, they are below all the major soils of this association.

Most of the acreage of this association is in native grass. It is generally too steep and stony for cultivation, but a few tracts of Benfield soils are cultivated. Many areas are overgrown with osageorange and locust, and with woody bush. The more desirable walnut, hickory, oak, and elm are along a few drainage-

ways and lower slopes. The main enterprise is grazing beef cattle.

These shallow and moderately deep soils are droughty during periods of little rainfall. Water erosion is a hazard on the moderately steep and very steep soils. Maintaining an adequate grass cover is an important concern of management. The cover can be maintained by well-regulated grazing. Grass production is low in some areas. Gullies form in drainage-ways. Weeds, brush, and undesirable trees need to be controlled.

Only a few farmsteads are in this association. Roads are on most section lines and are mainly unpaved. A few roads are surfaced with crushed rock. Livestock are generally sold at auction in local sale rings, are contracted on the farm, or are trucked to large terminals, such as St. Joseph, Missouri. A few springs and a few farm ponds supply water for livestock.

Descriptions of the Soils

This section describes the soil series and mapping units in Pawnee County. Each soil series is described in detail, and then, briefly, each mapping unit in that series is described. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative of mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in the description of the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for moist soil unless otherwise stated.

As mentioned in the section "How this Survey was Made," not all mapping units are members of a soil series. Wet alluvial land, for example, does not belong to a soil series but, nevertheless, is listed in alphabetic order along with the soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, range site, and windbreak suitability group in which the mapping unit has been placed. The page for the description of each capability unit, range site, or windbreak suitability group can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the "Glossary" at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (4).

A given soil series in this county may be identified by a different name in a recently published soil survey of an adjacent county. Some soil boundaries may not match adjoining areas. Such differences result from changes in concepts of soil classification that have occurred since publication.

Benfield Series

The Benfield series consists of moderately deep, well-drained soils on uplands. These soils formed in material that weathered from the underlying silty and clayey shale. They are gently sloping to moderately steep.

In a representative profile the surface layer is very dark brown silty clay loam 14 inches thick. The upper 20 inches of the subsoil is dark-brown, very firm silty clay. The lower 5 inches is olive-gray, firm silty clay loam. The underlying material is olive-gray, olive-brown, yellowish-brown, and brownish-yellow interbedded silty and clayey shale.

Permeability is slow and available water capacity is moderate. Natural fertility is high, except in severely eroded areas. The surface layer is lightly acid. Moisture is released slowly to plants.

Benfield soils are suited to cultivated crops and grasses. They are also suitable for use by wildlife and for recreation. Trees can be grown in windbreaks.

Representative profile of Benfield silty clay loam, 3 to 9 percent slopes, eroded, in a bluegrass pasture 0.45 mile west and 0.18 mile south of the center of sec. 13, T. 2 N., R. 12 E.:

- A11—0 to 8 inches, very dark brown (10YR 2/2) light silty clay loam, dark gray (10YR 4/1) dry; moderate, very fine and fine, granular structure; slightly hard, very friable; slightly acid; gradual, smooth boundary.
- A12—8 to 14 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; strong, medium and fine, granular structure; hard, friable; slightly acid; gradual, wavy boundary.
- B21t—14 to 26 inches, dark-brown (10YR 3/3) silty clay, dark brown (7.5YR 4/4) dry; weak, coarse and medium, blocky structure; very hard, very firm; shiny surfaces on faces of peds; slightly acid; gradual, wavy boundary.
- B22t—26 to 34 inches, dark-brown (7.5YR 4/4) silty clay, brown (7.5YR 5/4) dry; weak, coarse and medium, angular blocky structure; very hard, very firm; shiny surfaces on faces of peds; mildly alkaline; gradual, wavy boundary.
- B3—34 to 39 inches, olive-gray (5Y 5/2) heavy silty clay loam, light gray (5Y 7/2) dry; fine, distinct, yellowish-brown (10YR 5/6), light olive-brown (2.5Y 5/6), and brown (10YR 5/3) mottles; weak, coarse, angular blocky structure; very hard, firm; neutral; clear, wavy boundary.
- C—39 to 60 inches, olive-gray (5Y 5/2), olive-brown (2.5Y 4/4), yellowish-brown (10YR 5/4), and brownish-yellow (10YR 6/6) interbedded silty and clayey shale, mixed light gray (5Y 7/2), light olive brown

TABLE 1.—Approximate acreage and proportionate extent of the soils

Soil	Area	Extent	Soil	Area	Extent
	<i>Acres</i>	<i>Percent</i>		<i>Acres</i>	<i>Percent</i>
Benfield silty clay loam, 3 to 9 percent slopes, eroded	2,777	1.0	Pawnee loam, 0 to 3 percent slopes	493	0.2
Benfield soils, 3 to 9 percent slopes, severely eroded	1,704	.6	Pawnee loam, 3 to 9 percent slopes	14,410	5.2
Burchard clay loam, 5 to 12 percent slopes	10,631	3.8	Pawnee clay loam, 3 to 9 percent slopes, eroded	24,633	8.9
Burchard clay loam, 12 to 17 percent slopes	2,667	1.0	Pawnee soils, 3 to 9 percent slopes, severely eroded	29,837	10.8
Butler silt loam	353	.1	Pawnee and Mayberry soils, 9 to 12 percent slopes, severely eroded	1,676	.6
Colo and Kennebec soils, occasionally flooded	15,926	5.7	Rough broken and gullied land	4,141	1.5
Crete silt loam, terrace	1,280	.5	Shelby clay loam, 5 to 12 percent slopes	9,411	3.4
Judson silt loam, 1 to 5 percent slopes	14,205	5.1	Shelby and Burchard clay loams, 12 to 17 percent slopes	2,330	.8
Kennebec silt loam	5,762	2.1	Silty alluvial land	4,825	1.7
Kipson-Benfield silty clay loams, 5 to 17 percent slopes	7,906	2.8	Steinauer clay loam, 5 to 12 percent slopes	3,048	1.1
Kipson-Sogn complex	4,014	1.4	Steinauer clay loam, 12 to 21 percent slopes	5,699	2.1
Malcolm complex, 5 to 12 percent slopes	1,125	.4	Wabash silty clay loam	6,039	2.2
Malcolm complex, 12 to 25 percent slopes	1,567	.6	Wabash silty clay	1,295	.5
Mayberry loam, 3 to 9 percent slopes	2,859	1.0	Wet alluvial land	814	.3
Mayberry clay loam, 3 to 9 percent slopes, eroded	7,251	2.6	Wymore silty clay loam, 0 to 3 percent slopes	3,903	1.4
Mayberry soils, 3 to 9 percent slopes, severely eroded	10,451	3.8	Wymore silty clay loam, 3 to 7 percent slopes	2,097	.8
Morrill loam, 3 to 5 percent slopes	998	.4	Wymore silty clay loam, 3 to 7 percent slopes, eroded	53,654	19.4
Morrill loam, 5 to 12 percent slopes	8,725	3.1	Wymore soils, 3 to 7 percent slopes, severely eroded	4,461	1.6
Morrill loam, 12 to 17 percent slopes	868	.3	Pits and quarries	113	(¹)
Morrill soils, 5 to 12 percent slopes, severely eroded	2,127	.8	Water areas of less than 40 acres	224	.1
Morrill soils, 12 to 17 percent slopes, severely eroded	333	.1	Stream channels	488	.2
			Total land area	277,120	100.0

¹ Less than 0.05 percent.

(2.5Y 5/4), light yellowish brown (10YR 6/4), and yellow (10YR 2/6) dry; weak, fine to coarse, platy structure; very hard, very firm; strong effervescence; moderately alkaline.

The A horizon ranges from 7 to 16 inches in thickness, from light silty clay loam to silty clay in texture, and from black to dark brown in color. In severely eroded areas the A horizon is thinner, lighter colored, and finer textured than it is in other areas. It ranges from slightly acid to mildly alkaline. The B2 horizon ranges from very dark grayish brown to brown. The B3 horizon is yellowish brown, olive gray, light olive brown, olive, or reddish brown. Depth to the C horizon ranges from 20 to 40 inches.

Benfield soils, 3 to 9 percent slopes, severely eroded, have a surface layer that is thinner and lighter colored than is defined as within the range for the Benfield series.

Benfield soils are associated in the landscape with Kipson soils. They are deeper and more acid than Kipson soils, though they weathered from the same bedrock material. Benfield soils have a B horizon, which is lacking in Kipson soils.

Benfield silty clay loam, 3 to 9 percent slopes, eroded (BbC2).—This soil borders intermittent drainageways that flow toward the valleys of Turkey Creek and the Big Nemaha River. In places limestone rocks are at the surface.

This soil has the profile described as representative of the series. Included with this soil in mapping were a few areas of uneroded soils, a few areas of severely eroded soils, and a few areas where the subsoil is reddish brown. Small areas of Kipson soils were also included.

This soil requires skilled management. The principal hazard is water erosion. Because the subsoil is clayey, the soil dries slowly during wet season and slowly releases moisture to plants during hot and dry seasons.

Runoff is medium or rapid, depending on the amount of plant cover. Workability is only fair. Maintaining fertility and improving the content of organic matter are further concerns of management.

This soil is used for both cultivated crops and grasses. Use depends on the size of the soil area, the choice of the farmer, and the kind of farming practiced. Capability unit IIIe-2; Clayey range site; wind-break suitability group 5.

Benfield soils, 3 to 9 percent slopes, severely eroded (BbC3).—These soils are mainly along intermittent upland drainageways. They have a profile similar to the one described as representative of the series, but the surface layer is thinner and lighter colored. The surface layer is silty clay loam in places, and is silty clay in areas where erosion has been most severe. It is 5 to 8 inches thick. In most places the remaining part of the original surface layer has been mixed with the subsoil during cultivation.

Included with these soils in mapping were small tracts of Benfield silty clay loam, 3 to 9 percent slopes, eroded, that are adjacent to drainageways and in swales. Also included were small areas of Kipson soils and small areas of a soil that has a reddish-brown subsoil that formed in reddish shale.

These soils can be used for cultivated crops but are extremely limited by the severe hazard of erosion, poor tilth, low fertility, and a dense silty clay subsoil. Plowing extends into the clayey subsoil, and tilth is a serious concern of management. The exposed clays swell and shrink upon alternate wetting and drying. When dry, these soils are very hard; and when wet,

they are very sticky and plastic. These soils are droughty during periods of little rainfall.

Soils of this unit are used mainly for cultivated crops, but many areas have been reseeded to adapted native or introduced grasses. The soils are better suited to legumes and grasses than to row crops. Capability unit IVE-4; Dense Clay range site; windbreak suitability group 5.

Burchard Series

The Burchard series consists of deep, well-drained soils on uplands (fig. 6). These soils formed in brown-

rial is light brownish-gray and light olive-brown mottled clay loam that has seams of soft lime.

Permeability is moderately slow, and available water capacity is high. Natural fertility is high. Moisture is released readily to plants.

Burchard soils are suited to cultivated crops and to grasses. They can be used for windbreak plantings and as wildlife habitat and recreation areas.

Representative profile of Burchard clay loam, 5 to 12 percent slopes, in a grass meadow 725 feet west and 360 feet south of the center of sec. 32, T. 3 N., R. 10 E.:

- A11—0 to 7 inches, very dark brown (10YR 2/2) clay loam, very dark gray (10YR 3/1) dry; weak, medium and fine, subangular blocky structure parting to weak, fine, granular; slightly hard, friable; about 1 percent material coarser than $\frac{3}{4}$ inch; medium acid; gradual, smooth boundary.
- A12—7 to 13 inches, very dark grayish-brown (10YR 3/2) clay loam, dark gray (10YR 4/1) dry; weak, medium, subangular blocky structure parting to weak, fine, granular; slightly hard, friable; about 3 percent material coarser than $\frac{3}{4}$ inch; slightly acid; few gravel-sized pebbles and small stones near lower boundary; clear, wavy boundary.
- B1—13 to 20 inches, brown (10YR 5/3) and very dark grayish-brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) kneaded, pale brown (10YR 6/3) and dark grayish brown (10YR 4/2) dry; mixed by worms; moderate, medium and fine, subangular blocky structure; slightly hard, friable; about 2 percent material coarser than $\frac{3}{4}$ inch; neutral; clear, wavy boundary.
- B2t—20 to 26 inches, olive-brown (2.5Y 4/4) clay loam, light yellowish brown (2.5Y 6/4) dry; moderate, medium and fine, subangular blocky structure; slightly hard, friable; about 1 percent material coarser than $\frac{3}{4}$ inch; few small, soft accumulations of segregated lime; small, dark worm casts; strong effervescence; gradual, wavy boundary.
- B3—26 to 40 inches, grayish-brown (2.5Y 5/2) clay loam, light gray (2.5Y 7/2) dry; light olive-brown (2.5Y 5/4) mottles; weak, medium, subangular and angular blocky structure; hard, firm; about 2 percent material coarser than $\frac{3}{4}$ inch diameter; many small lime concretions; few soft streaks of lime; strong effervescence; clear, wavy boundary.
- C1—40 to 54 inches, light brownish-gray (2.5Y 6/2) clay loam, light gray (2.5Y 7/2) dry; strong-brown (7.5YR 5/6) mottles; weak, medium and coarse, angular blocky structure; hard, friable; about 2 percent material coarser than $\frac{3}{4}$ inch; few small lime concretions; common small streaks of soft lime; strong effervescence; gradual, smooth boundary.
- C2—54 to 60 inches, light brownish-gray (2.5Y 6/2) and light olive-brown (2.5Y 5/4) clay loam, light gray (2.5Y 7/2) and light yellowish brown (2.5Y 6/4) dry; grayer adjacent to seams of lime; many coarse, brown (7.5YR 5/4) mottles; weak, coarse, angular blocky structure; hard, firm; about 2 percent material coarser than $\frac{3}{4}$ inch; common small seams of soft lime; strong effervescence.

The A horizon ranges from 7 to 18 inches in thickness. In a few small, eroded areas the A horizon is gravelly clay loam. In these areas the fine material has eroded away, leaving coarse sand, pebbles, and stones on the surface. This horizon ranges from black to very dark grayish brown. It ranges from medium acid to neutral. The B horizon ranges from 17 to 32 inches in thickness. It ranges from very dark grayish brown in the upper part to light olive brown in the lower part. This horizon is 27 to 35 percent clay. A few pebbles and stones are throughout the soil. In a few places, thin layers and pockets of sand are



Figure 6.—Profile of Burchard clay loam. This deep, friable soil formed in glacial till.

ish to grayish, limy glacial deposits. They are gently sloping to moderately steep.

In a representative profile the surface layer is clay loam about 13 inches thick. It is very dark brown in the upper part and very dark grayish brown in the lower part. The subsoil is friable clay loam about 27 inches thick. The upper part is brown and very dark grayish brown; the middle part is olive brown; and the lower part is grayish brown. The underlying mate-

below a depth of 40 inches. Depth to lime ranges from 13 to 30 inches.

Burchard soils are associated in the landscape with Shelby, Steinauer, and Pawnee soils. Burchard soils have lime higher in the profile than Shelby soils. They have a darker, thicker A horizon than Steinauer soils, and they have a B horizon that is lacking in Steinauer soils. Burchard soils have less clay in the B horizon than Pawnee soils.

Burchard clay loam, 5 to 12 percent slopes (BdD).—This soil is the lower parts of hillsides in the Turkey Creek, Wolf Creek, and Plum Creek drainage area. The areas are irregularly shaped and range in size from 5 to 35 acres. A few glacial boulders are on the surface.

This soil has the profile described as representative of the series. Included with this soil in mapping were small areas of Shelby and Steinauer soils and few areas of severely eroded soils that have a thinner, lighter colored surface layer than is defined as within the range for the Burchard series. Where the soil is eroded, the surface layer is commonly gravelly clay loam.

Water erosion is the main hazard on this soil. Runoff is medium to rapid, depending on the amount of plant cover. Conserving surface water and maintaining fertility are concerns of management. Water, air, and roots penetrate this soil readily. This soil is easily worked.

About 65 percent of the acreage of this soil is in grass, and about 35 percent is cultivated. This soil is well suited to alfalfa, clover, and grasses. Grain sorghum, wheat, and corn are also grown. Capability unit IIIe—1, Silty range site; windbreak suitability group 4.

Burchard clay loam, 12 to 17 percent slopes (BdE).—This soil is on hillsides. The areas are small and irregularly shaped.

This soil has a profile similar to the one described as representative of the series, but the surface layer and subsoil are slightly thinner. Included with this soil in mapping were small tracts of Steinauer and Shelby soils.

Water erosion is a severe hazard on this soil. The use of large machinery is limited on the moderately steep soils. Runoff is rapid and needs to be controlled. Maintaining fertility is a concern of management.

Most of the acreage of this soil is in grass. The soil is well suited to this use. A small acreage is in close-growing crops that grow well in the limy subsoil. Alfalfa and clover are especially well suited to this soil. Wheat is also grown. Capability unit IVE—1, Silty range site; windbreak suitability group 4.

Butler Series

The Butler series consists of deep, somewhat poorly drained soils that have a claypan subsoil. These soils formed in loess on uplands.

In a representative profile the surface layer is silt loam. The upper part is black and about 9 inches thick. The lower part is very dark gray and about 3 inches thick. The subsoil is about 38 inches thick. The upper part is black, very firm silty clay, and the lower part is very dark grayish-brown, firm heavy silty clay

loam. The underlying material, extending to a depth of 60 inches, is olive-gray silty clay loam.

Permeability is slow and available water capacity is high. Natural fertility is high. The surface layer is slightly acid. Moisture is released slowly to plants.

Butler soils are suited to cultivated crops, grasses, and trees. They are used as wildlife habitat and have minor potential for recreational use.

Representative profile of Butler silt loam in a cultivated field 0.35 mile west and 250 feet north of the center of sec. 31, T. 1 N., R. 9 E.:

Ap—0 to 9 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; moderate, very fine, crumb structure; slightly hard, very friable; slightly acid; clear, smooth boundary.

A2—9 to 12 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 6/1) dry; weak, very fine, crumb structure; soft, very friable; slightly acid; abrupt, smooth boundary.

B2t—12 to 34 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; strong, medium, angular blocky structure; extremely hard, very firm; shiny surfaces on faces of peds; neutral; gradual, smooth boundary.

B3t—34 to 50 inches, very dark grayish-brown (2.5Y 3/2) heavy silty clay loam, dark gray (10YR 4/1) dry; moderate, medium and coarse, angular blocky structure; very hard, firm; few lime concretions; patchy shiny surfaces on faces of peds; moderately alkaline; gradual, smooth boundary.

C—50 to 60 inches, olive-gray (5Y 5/2) silty clay loam, light olive gray (5Y 6/2) dry; many, fine and medium, distinct, strong-brown (7.5Y 5/6) mottles; weak, coarse, blocky structure; hard, friable; slight effervescence; mildly alkaline.

The A horizon ranges from 5 to 10 inches in thickness and from black to very dark grayish brown in color. The B horizon ranges from 25 to 40 inches in thickness. The B2t horizon ranges from very dark gray to black. The B2t is 45 to 55 percent clay. Depth to lime ranges from 26 to 54 inches.

Butler soils occur in the landscape with Wymore soils. They have an A2 horizon that is lacking in Wymore soils, and they are more poorly drained.

Butler silt loam (0 to 1 percent slopes) (Bu).—This soil is at the heads of upland drainageways. The areas range from 5 to 35 acres in size. Included in mapping were a few small areas of Wymore soils.

During wet periods, slow runoff and slow permeability cause this soil to stay wet longer than the surrounding soils. Surface drainage is needed in many areas. Tillage is commonly delayed because of wetness. The claypan subsoil can limit movement of roots. Although the soil is deep, it can be droughty because the surface layer is the only part that effectively stores available moisture. Maintaining fertility of the soil is a concern of management.

Wheat, grain sorghum, and clover are the commonly grown crops. Corn and soybeans are also grown. Nearly all areas are cultivated. Capability unit IIw—2; Clayey range site; windbreak suitability group 2.

Colo Series

The Colo series consists of deep, somewhat poorly drained soils on bottom land. These soils formed in silty alluvium. They are nearly level. Depth to the water table ranges from 3 to 8 feet.

In a representative profile the surface layer is very dark brown and black silty clay loam about 30 inches

thick. The underlying material, extending to a depth of 60 inches, is firm, very dark gray silty clay loam. It contains many faint, dark-brown mottles.

Permeability is moderately slow, and available water capacity is high. Natural fertility is high. The upper part of the surface layer is neutral. Moisture is released readily to plants.

In Pawnee County, Colo soils were mapped in an undifferentiated group with Kennebec soils.

Colo soils are suited to cultivated crops and to grasses. Trees grow well in windbreaks. Wildlife use the areas of these soils as habitat and as a source of food. These soils have limited potential for use as recreation areas.

Representative profile of Colo silty clay loam in an area of Colo and Kennebec soils, occasionally flooded, in a tame pasture 0.35 mile north and 420 feet east of the southwest corner of sec. 3, T. 2 N., R. 10 E.:

- Ap—0 to 7 inches, very dark brown (10YR 2/2) silty clay loam, dark gray (10YR 4/1) dry; weak, coarse, blocky structure parting to weak, fine and medium, subangular blocky; slightly hard, friable; neutral; abrupt, wavy boundary.
- A12—7 to 13 inches, black (10YR 2/1) light silty clay loam, very dark gray (10YR 3/1) dry; moderate, fine, granular structure; slightly hard, friable; neutral; gradual, smooth boundary.
- A13—13 to 20 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate, fine and medium, granular structure; slightly hard, friable; slightly acid; gradual, smooth boundary.
- A14—20 to 30 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate, very fine and fine, blocky structure; hard, firm; slightly acid; gradual, smooth boundary.
- Cg—30 to 60 inches, very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; many, faint, dark-brown (10YR 3/3) mottles; weak, coarse and medium, blocky structure; hard, firm; few shiny surfaces on faces of peds; slightly acid.

The A horizon ranges from 20 to 40 inches in thickness, and from silt loam to silty clay loam in texture, and from black to very dark brown or very dark gray in color. It is slightly acid to neutral. The underlying material is very dark gray or dark gray. In places, a layer of light silty clay material is below a depth of 40 inches. The underlying material ranges from slightly acid to neutral. In a few small seep spots, concretions of hard lime are below a depth of 40 inches.

Colo soils occur in the landscape with Kennebec and Wabash soils. They are not so well drained as Kennebec soils, and they have a higher water table. Colo soils are not so fine textured in the lower part of the A horizon and in the C horizon as Wabash soils.

Colo and Kennebec soils, occasionally flooded (0 to 1 percent slopes) (Ck).—These soils are mainly on narrow valleys of small streams. The areas are long, continuous strips of bottom land. Some areas are made up entirely of Colo soils, others are entirely Kennebec soils, and other areas are made up of both soils.

The Kennebec soil in this mapping unit has a profile similar to the one described as representative for the series, except that the surface layer is slightly lighter colored.

Included with these soils in mapping were areas of soils that have 7 to 30 inches of silty overwash sediment on the surface. In places are soils that have fine, olive-brown mottles at a depth of about 40 inches. Also included were areas of soils that have clayey layers below a depth of 30 inches.

These soils tend to dry slowly in spring and are subject to occasional overflow. Wetness is the principal hazard, and surface drainage is needed in places. Otherwise, these are good, tillable soils that absorb water readily, store moisture well, are fertile, and are fairly easy to work if they are well managed. Maintaining fertility is a concern of management.

Most areas of these soils are used for corn and grain sorghum, but some are used for wheat, soybeans, and clover. Although these soils are well suited to alfalfa, only a small acreage is used for this crop. A few tracts are overgrown with trees and brush; a few narrow valleys along the upper reaches of streams are in grass and are used, along with the adjoining uplands, as pasture; and a few small timbered areas, consisting of stands of black walnut, oak, and hackberry, are used for veneer logs and lumber products. Capability unit IIw-3; Colo part in Silty Overflow range site; Kennebec part in Silty Lowland range site; Colo part in windbreak suitability group 2 and Kennebec part in windbreak suitability group 1.

Crete Series

The Crete series consists of deep, moderately well drained soils on low stream terraces. These soils formed in loess. They are nearly level or very gently sloping.

In a representative profile the surface layer is black silt loam about 10 inches thick. The subsoil is about 40 inches thick. The upper part is very dark brown, friable silty clay loam; the middle part is very dark grayish-brown and dark grayish-brown, very firm silty clay; and the lower part is dark-brown, firm silty clay loam. The underlying material at a depth of 50 inches is brown, mottled silty clay loam.

Permeability is slow and available water capacity is high. Natural fertility is high. The surface layer is slightly acid. Moisture is released slowly to plants.

Crete soils are suited to cultivated crops, grasses, and trees in windbreaks. Wildlife use areas of these soils as habitat and as a source of food. These soils have limited potential use as recreation areas.

Representative profile of Crete silt loam, terrace, in a cultivated field 0.55 mile east and 0.42 mile north of the southwest corner of sec. 17, T. 3 N., R. 12 E.:

- Ap—0 to 10 inches, black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; moderate, fine, granular structure; slightly hard, friable; slightly acid; gradual, smooth boundary.
- B1—10 to 19 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; moderate, very fine and fine, subangular blocky structure; hard, friable; slightly acid; gradual, smooth boundary.
- B21t—19 to 30 inches, very dark grayish-brown (10YR 3/2) silty clay, dark grayish brown (10YR 4/2) dry; moderate, medium and fine, blocky structure; very hard, very firm; thin coatings on faces of peds; neutral; gradual, smooth boundary.
- B22t—30 to 38 inches, dark grayish-brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) dry; moderate, medium and fine, blocky structure; very hard, very firm; shiny surfaces on faces of peds; thin band of lime concretions at depth of 36 inches; mildly alkaline; gradual, smooth boundary.
- B3t—38 to 50 inches, dark-brown (10YR 4/3) heavy silty clay loam, brown (10YR 5/3) dry; common, fine,

faint, grayish-brown (10YR 5/2) and brown (10YR 5/4) mottles; weak, medium and coarse, blocky structure; few patchy coatings on faces of peds; very hard, firm; mildly alkaline; gradual, smooth boundary.

C—50 to 60 inches, brown (10YR 5/3) silty clay loam, pale brown (10YR 6/3) dry; common, fine, faint, grayish-brown (10YR 5/2) and dark-brown (10YR 5/3) mottles; weak, coarse, blocky structure; hard, friable; mildly alkaline.

The A horizon ranges from 7 to 20 inches in thickness. It is black or very dark brown. The B horizon ranges from 25 to 42 inches in thickness. The B2 horizon is 45 to 52 percent clay. In places where these soils formed in thin loess deposits, they are underlain by loesslike alluvium.

Crete soils occur in the landscape with Wymore soils. They have a darker B2t horizon than Wymore soils. In places Crete soils are adjacent to Wabash soils that are at lower elevations. Crete soils have coarser textured underlying material and are better drained than Wabash soils.

Crete silt loam, terrace (0 to 3 percent slopes) (Cr).—This soil is on low stream terraces. Included in mapping were small areas where the surface layer is more than 20 inches thick.

Because the clayey subsoil is slowly permeable, this soil is sometimes droughty. Water is stored most effectively in the upper 19 inches of the soil. The subsoil holds moisture tightly. Maintaining fertility is a concern of management. This soil is easy to till. Surface runoff is slow.

Wheat and grain sorghum are the most commonly grown crops. Corn, soybeans, and legumes are also grown. Nearly all of the acreage is cultivated. Capability unit IIs-2; Clayey range site; windbreak suitability group 4.

Judson Series

The Judson series consists of deep, well-drained soils on foot slopes. These soils formed in a mixture of loess, alluvium, and colluvium. They are very gently sloping to gently sloping.

In a representative profile the surface layer is 27 inches thick. The upper part is very dark brown silt loam; the middle part is black light silty clay loam; and the lower part is very dark brown silty clay loam. The subsoil, extending to a depth of 60 inches, is silty clay loam. The upper part is friable and very dark grayish brown; the middle part is firm and dark brown; and the lower part is firm and brown.

Permeability is moderately slow and available water capacity is high. Natural fertility is high. The surface layer is slightly acid.

Judson soils are suited to cultivated crops, grasses, and trees in windbreaks. Wildlife use areas of these soils as habitat. These soils have limited potential for use as recreation areas.

Representative profile of Judson silt loam, 1 to 5 percent slopes, in a cultivated field 0.25 mile north, 0.42 mile east, and 200 feet south of the southwest corner of sec. 5, T. 3 N., R. 12 E.:

Ap—0 to 8 inches, very dark brown (10YR 2/2) silt loam, dark grayish brown (10YR 4/2) dry; weak, fine, granular structure; slightly hard, friable; slightly acid; abrupt, smooth boundary.

A12—8 to 16 inches, black (10YR 2/1) light silty clay loam, very dark gray (10YR 3/1) dry; moderate,

fine, granular structure; slightly hard, friable; slightly acid; clear, smooth boundary.

A13—16 to 27 inches, very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; strong, fine and medium, granular structure; hard, friable; slightly acid; gradual, smooth boundary.

B21—27 to 33 inches, very dark grayish-brown (10YR 3/2) silty clay loam, dark grayish brown (10YR 4/2) dry; moderate, very fine and fine, subangular blocky structure; hard, friable; slightly acid to neutral; clear, smooth boundary.

B22—33 to 44 inches, dark-brown (10YR 3/3), rubbed silty clay loam, brown (10YR 5/3) dry; very dark grayish-brown ped exteriors; moderate, medium, subangular blocky structure; very hard, firm; neutral; clear, smooth boundary.

B3—44 to 60 inches, brown (10YR 4/3), rubbed heavy silty clay loam, brown (10YR 5/3) dry; dark grayish-brown (10YR 4/2) ped exteriors; few, fine, grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/4) mottles; weak, medium and coarse, angular blocky structure; very hard, firm; neutral.

The A horizon ranges from 20 to 36 inches in thickness. It is black to very dark grayish brown. Reaction ranges from slightly acid to neutral. The B horizon ranges from 15 to 35 inches in thickness. In places, a grayish coat covers the outside of undisturbed aggregates of subsoil. The color of rubbed soil ranges from dark brown to dark yellowish brown. Mottles range from few to common, from faint to distinct, and from grayish brown to yellowish brown. The mottles are below a depth of 40 inches.

Where Judson soils are adjacent to bottom lands, they are associated with Kennebec soils. Where they are adjacent to uplands, they are associated with Wymore soils. Judson soils are not so dark in most parts of the A horizon as Kennebec soils, and they have a B horizon, which is lacking in Kennebec soils. Judson soils have less clay in the B2 horizon and have a thicker A horizon than Wymore soils.

Judson silt loam, 1 to 5 percent slopes (JuC).—This soil is in long, narrow areas at the bases of upland slopes.

Included with this soil in mapping were a few areas of soils that have a silty clay loam surface layer and an area of a soil that contains lenses and pockets of sandy material in the surface layer. In places, glacial till or alluvium are below a depth of 40 inches. Also included in mapping were small areas of Kennebec and Colo soils.

Water erosion is the principal hazard to cultivation of this soil. Maintaining fertility is a concern of management. Moisture is absorbed, stored, and released readily to plants.

Most areas of this soil are used for cultivated crops. Small tracts are used as range, especially where the adjacent areas are in grass. Corn, grain sorghum, wheat, clover, and alfalfa are the commonly grown crops. Capability unit IIs-1; Silty Lowland range site; windbreak suitability group 4.

Kennebec Series

The Kennebec series consists of deep, moderately well drained soils on bottom land. These soils formed in silty and loamy alluvium (fig. 7). They are nearly level.

In a representative profile the surface layer is black silt loam about 30 inches thick. The transitional layer between the surface layer and underlying material is

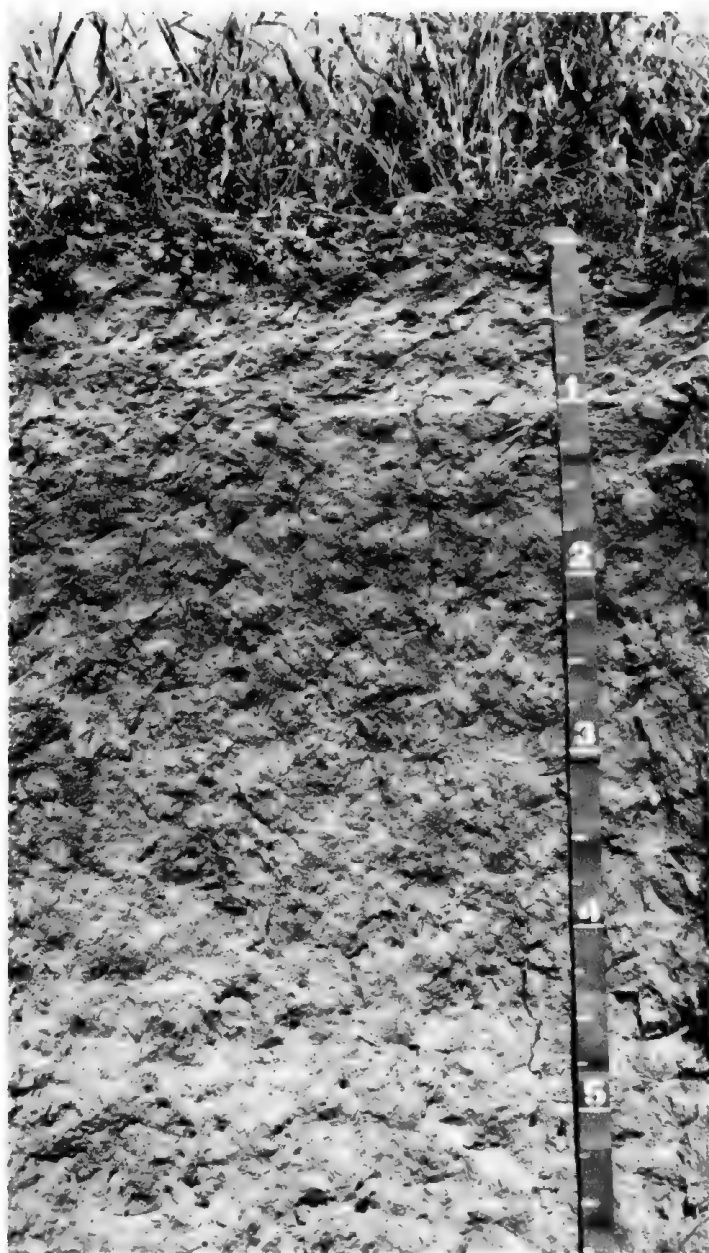


Figure 7.—Profile of Kennebec silt loam. The top 12 inches has been plowed and is lighter colored than the rest of the surface layer.

about 12 inches of very dark gray, friable silt loam. The underlying material is at a depth of 42 inches. It is very dark grayish-brown silt loam in the upper part. Beneath this, and extending to a depth of 60 inches, it is dark grayish-brown loam.

Permeability is moderate and available water capacity and natural fertility are high. The surface layer is slightly acid.

Kennebec soils are suited to cultivated crops, grasses, and trees in windbreaks. Wildlife use areas of these soils as habitat and as a source of food. The soils have only limited potential for use as recreation areas.

Representative profile of Kennebec silt loam 2,790 feet north and 425 feet west of the southeast corner of sec. 137, T. 3 N., R. 12 E.:

- Ap—0 to 8 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) dry; weak, coarse, blocky structure parting to weak, fine, granular; soft, friable; slightly acid; clear, smooth boundary.
- A12—8 to 15 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) dry; weak, coarse, blocky structure parting to moderate, fine, granular; slightly hard, friable; slightly acid; gradual, smooth boundary.
- A13—15 to 30 inches, black (10YR 2/1) heavy silt loam, dark gray (10YR 4/1) dry; weak, coarse and medium, blocky structure parting to moderate, medium, granular; slightly hard, friable; slightly acid; gradual, smooth boundary.
- AC—30 to 42 inches, very dark gray (10YR 3/1) heavy silt loam, dark gray (10YR 4/1) dry; moderate, medium, blocky structure; slightly hard, friable; neutral; gradual, smooth boundary.
- C1—42 to 50 inches, very dark grayish-brown (10YR 3/2) heavy silt loam, dark grayish brown (10YR 4/2) dry; weak, medium, blocky structure; slightly hard, friable; neutral; gradual, smooth boundary.
- C2—50 to 60 inches, dark grayish-brown (10YR 4/2) loam, grayish brown (10YR 5/2) dry; weak, coarse, blocky structure; soft, very friable; neutral.

The A horizon ranges from 27 to 45 inches in thickness. It ranges from black to very dark grayish brown. In places, Kennebec soils have thin, very dark grayish-brown or dark grayish-brown silty overwash sediment on the surface. The A horizon ranges from slightly acid to neutral. The AC horizon ranges from 9 to 12 inches in thickness, from silt loam to light silty clay loam in texture, and from black to very dark grayish brown in color. The AC horizon is slightly acid to neutral. The underlying material is very dark grayish brown or dark grayish brown. It ranges from loam to heavy silty clay loam. In places, Kennebec soils have a clayey substratum or a buried dark A horizon below a depth of 40 inches.

Kennebec soils are associated in the landscape with Colo, Judson, and Wabash soils. Kennebec soils are better drained than Colo soils, and they are not so fine textured. Kennebec soils have a darker A horizon than Judson soils, and they lack a B horizon, which the Judson soils have. Kennebec soils are not so fine textured as the Wabash soils, and they are better drained.

Kennebec silt loam (0 to 1 percent slopes) (Ke).—This soil is mainly on the bottom lands of the North Fork and South Fork of the Big Nemaha River and its tributaries. A few areas are in other stream valleys in the county.

This soil has the profile described as representative of the series. Included with this soil in mapping were small areas of a soil that has dark grayish-brown overwash sediment on the surface; some areas of a soil that has silty clay loam at a depth of about 24 inches; and some areas of a soil that has clayey material below a depth of 40 inches. Also included in mapping were small tracts of Wabash silty clay loam.

This Kennebec soil is excellent for cultivated crops. It is seldom flooded, has few limitations for farming, and responds well to good management practices. Moisture is absorbed readily. Maintaining fertility is a concern of management.

Nearly all of the acreage of this soil is cultivated. Corn and grain sorghum are the commonly grown crops. Legumes, soybeans, and grasses are also grown. Capability unit I-1; Silty Lowland range site; windbreak suitability group 1.

Kipson Series

The Kipson series consists of shallow, somewhat excessively drained soils on uplands (fig. 8). These soils



Figure 8.—Profile of Kipson silty clay loam, a shallow soil over bedrock.

formed in material weathered from interbedded silty and clayey shale and soft limestone bedrock. They are gently sloping to very steep.

In a representative profile the surface layer is very dark grayish-brown silty clay loam about 9 inches thick. It is about 20 percent limestone fragments. The transitional layer between the surface layer and the underlying material is brown, friable silty clay loam. At a depth of 17 inches is mixed pale-yellow and light olive-brown interbedded silty and clayey shale bedrock.

Permeability is moderately slow, and available water capacity and natural fertility are low. The surface layer is moderately alkaline. Moisture is released readily to plants.

Kipson soils are suited to grasses. They are also suited to trees in windbreaks in areas where slopes are not too steep. These soils are not suited to cultivated crops because they are too shallow and rocky, and because most areas are too steep. They are suitable

for use as wildlife habitat and as recreation areas.

Representative profile of Kipson silty clay loam in an area of Kipson-Benfield silty clay loams, 5 to 17 percent slopes, in a pasture 0.3 mile north and 65 feet west of the southeast corner of sec. 32, T. 1 N., R. 12 E.:

- A—0 to 9 inches, very dark grayish-brown (10YR 3/2) silty clay loam, grayish brown (10YR 5/2) dry; moderate, medium, granular structure; hard, friable; about 20 percent limestone fragments one-fourth to 1 inch thick and 1 to 10 inches long; strong effervescence; moderately alkaline; gradual, wavy boundary.
- AC—9 to 17 inches, brown (10YR 5/3) silty clay loam, pale brown (10YR 6/3) dry; weak, fine, subangular blocky structure; hard, friable; few small limestone fragments; strong effervescence; moderately alkaline; clear, wavy boundary.
- C—17 to 36 inches, pale-yellow (5Y 7/3) and light olive-brown (2.5Y 5/4) silty and clayey shale, mixed white (5Y 8/2) and light yellowish brown (2.5Y 6/4) dry; soft to very hard, friable to very firm; scattered limestone fragments; strong effervescence.

The A horizon is black to very dark grayish-brown silty clay loam that ranges from 5 to 16 inches in thickness. The quantity of coarse limestone fragments varies greatly, and ranges from 0 to 50 percent. The fragments are loosely incorporated and range in size from one-fourth inch to 15 inches. The AC horizon ranges from 0 to 9 inches in thickness. It ranges from dark brown, brown, and dark grayish brown to light olive brown, olive brown, olive gray, and olive. The quantity of coarse fragments varies greatly. The C horizon ranges from silty shale to clayey shale to layers of soft limestone. In places it is soft sandstone. The thickness of each layer of shale ranges from one-half foot to about 6 feet. The shale is mostly pale yellow and light olive brown but is reddish brown in places.

Kipson soils occur in the landscape with Benfield and Sogn soils. They are shallower over shale bedrock than Benfield soils and they lack a clayey B horizon, which the Benfield soils have. Kipson soils formed in material weathered from shale, and Sogn soils formed in material weathered from limestone.

Kipson-Benfield silty clay loams, 5 to 17 percent slopes (KfE).—These soils are on hillsides bordering the valleys of the North Fork and South Fork of the Big Nemaha River and Turkey Creek.

The Kipson soils in this complex have the profile described as representative of the series. The Benfield soils have a profile that is similar to the one described as representative of the series, but the subsoil is slightly thinner and not quite so well developed. Kipson and Benfield soils each make up about 45 percent of this mapping unit.

Included with these soils in mapping were areas of Morrill soils. Also included were small areas of Rough broken and gullied land; Silty alluvial land; and Judson, Sogn, and Wymore soils. In places, bedrock crops out at the surface.

The low available water capacity and rocky nature of the Kipson soils are the principal characteristics that influence the use of these soils. Runoff is rapid. Roots of most plants can penetrate the soft shale. They can penetrate the limestone bedrock in crevices and fractures. Many areas have sudden changes in slope, and these changes make use of machinery difficult and cultivation impractical. The hazard of erosion is severe if the natural cover is destroyed. In overgrazed areas, gullies form in natural drainageways,

and woody brush invades the grassland.

These soils are best suited to perennial grasses, and most of the acreage is in grass. A small acreage is cultivated. Small wooded areas are used as wildlife habitat and for producing minor wood products. Capability units IVs-4; Kipson part in Shallow Limy range site and windbreak suitability group 10; Benfield part in Clayey range site and windbreak suitability group 5.

Kipson-Sogn complex (12 to 60 percent slopes) (KsF).—These soils are on knolls and on irregular hillsides that border the valleys of the North Fork and South Fork of the Big Nemaha River and Turkey Creek. About 60 percent of this complex is Kipson soils and about 25 percent is Sogn soils.

Included with these soils in mapping are areas of Benfield soils. Also included are small areas of Judson soils and Rough broken and gullied land.

The Kipson soils in this complex have a profile similar to the one described as representative of the series, but they are slightly shallow over the underlying shale. The surface layer of Kipson and Sogn soils is dominantly silty clay loam. It is stony loam and stony silty clay loam in places.

These soils are too shallow, too stony, and too steep for cultivation. Available water capacity is low to very low. In places, short, very steep slopes are adjacent to stream channels that have limestone bedrock bottoms. Small to large limestone fragments are common on the surface of these soils. The bedrock beneath Kipson soils is soft enough and fragmented enough in places to permit root penetration. The bedrock beneath Sogn soils is too hard for roots to penetrate. In overgrazed rangeland, water erosion produces gullies in the drainageways, and woody plants invade the grassland.

Nearly all of the acreage of this mapping unit is in grasses, trees, and shrubs. Wildlife make good use of these soils as habitat. These soils are good for some kinds of recreation, such as hunting. Capability unit VIIs-4; Shallow Limy range site; windbreak suitability group 10.

Malcolm Series

The Malcolm series consists of deep, well-drained soils on uplands (fig. 9). These soils formed in grayish sediment deposited during interglacial times. They are moderately sloping to steep.

In a representative profile the surface layer is very dark brown silt loam about 10 inches thick. The next layer is very dark grayish-brown light silty clay loam about 5 inches thick. The subsoil is grayish-brown, friable silty clay loam about 20 inches thick. The underlying material, between depths of 35 and 60 inches, is light brownish-gray stratified silt loam, very fine sandy loam, and silty clay loam.

Permeability is moderate, and available water capacity is high. Natural fertility is medium. The surface layer is medium acid. Moisture is released readily to plants.

Malcolm soils are suited to cultivated crops where slopes are not too steep. They are also suited to grasses and to trees in windbreaks. They are used as wildlife habitat and, to a limited extent, as recreation areas.



Figure 9.—Profile of Malcolm silt loam. This soil formed in stratified sediment deposited during interglacial times.

Representative profile of Malcolm silt loam in an area of Malcolm complex, 12 to 25 percent slopes, used as range, 0.4 mile north and 100 feet east of the southwest corner of sec. 1, T. 3 N., R. 11 E.:

- A—0 to 10 inches, very dark brown (10YR 2/2) silt loam, dark gray (10YR 4/1) dry; moderate, fine, granular structure; slightly hard, very friable; medium acid; clear, smooth boundary.
- AB—10 to 15 inches, very dark grayish-brown (10YR 3/2) light silty clay loam, grayish brown (10YR 5/2) dry; moderate, fine and medium, granular structure; slightly hard, friable; parts of A horizon and B2 horizon in holes made by earthworms; slightly acid; clear, smooth boundary.
- B2—15 to 26 inches, grayish-brown (2.5Y 5/2) silty clay loam, light brownish gray (2.5Y 6/2) dry; moderate, very fine, subangular blocky structure; hard, friable; slightly acid; clear, smooth boundary.
- B3—26 to 35 inches, grayish-brown (2.5Y 5/2) silty clay loam, light gray (2.5Y 7/2) dry; common, prominent, large, dark yellowish-brown (10YR 4/4) mottles; moderate, fine and medium, subangular blocky structure; hard, friable; dark coatings on faces of peds in places; slightly acid; clear, smooth boundary.
- C—35 to 60 inches, light brownish-gray (2.5Y 6.5/2), strat-

ified silt loam, very fine sandy loam, and silty clay loam, light gray (2.5Y 7.5/2) dry; yellowish-brown (10YR 5/6) mottles; weak, medium and coarse, blocky structure; slightly hard, very friable; neutral.

The A horizon ranges from 6 to 15 inches in thickness. It is loam, very fine sandy loam, or silt loam. The AB horizon ranges from 8 to 16 inches in thickness. It ranges from silt loam to silty clay loam. The B horizon ranges from 15 to 25 inches in thickness. It is loam, silt loam, or silty clay loam. Color ranges from dark brown to grayish brown. The C horizon is generally silt loam or silty clay loam. In places, it contains thin layers of fine sand, very fine sand, and weathered clay. Color ranges from olive to light gray or pale brown.

Malcolm soils occur in the landscape with Morrill and Mayberry soils. The B horizon of Malcolm soils is neither so red nor so gritty as that of the Morrill soils. It is neither so red nor so clayey as that of Mayberry soils.

Malcolm complex, 5 to 12 percent slopes (McD).—The soils in this mapping unit are on hillsides that border drainageways leading to the North Fork of the Big Nemaha River.

About 45 percent of this complex is Malcolm soils; 20 percent is a soil similar to Malcolm soils, but which has a finer textured subsoil; and about 20 percent is Morrill soils. An additional 15 percent of this complex is made up of Mayberry soils, slickspots, sandy areas, and gravelly areas. The surface layer of these soils is mainly silt loam, but is silty clay loam, loam, and clay loam in places. The Malcolm soils have a profile similar to the one described as representative of the Malcolm series, but the surface layer is slightly thicker. The Morrill and Mayberry soils have profiles similar to the ones described as representative of their respective series, but the underlying material is grayish, stratified, interglacial sediment in places.

The small, circular slickspots in the complex are mainly clayey, strongly alkaline soil material that has poorly defined structure. The slickspots are nearly impervious to water and support only a thin plant cover. The small sandy and gravelly areas consist of stratified layers of sand and of pockets of gravel. A few of these areas are reworked glacial deposits.

Water erosion is a severe hazard if these soils are cultivated. Runoff is rapid. These soils are easy to till, except for the slickspots and the soils having a fine-textured surface layer. Maintaining fertility is a concern of management.

Part of this complex is cultivated and part is in grass. Alfalfa, clover, and wheat are the commonly grown crops. Corn and grain sorghum are also grown. Capability unit IVE-1; Silty range site; windbreak suitability group 4.

Malcolm complex, 12 to 25 percent slopes (McF).—These soils are in irregularly shaped areas on hillsides that border drainageways leading into the North Fork of the Big Nemaha River.

About 35 percent of this complex is Malcolm soils; about 25 percent is soil similar to Malcolm soils, but which has a finer textured, clayey subsoil; and about 25 percent is Morrill soils. An additional 15 percent of this complex is made up of small areas of Mayberry soils, slickspots, sandy areas, and gravelly areas. The surface layer of the soils in this complex is mainly silt loam, but is silty clay loam, loam, and clay loam in places.

The Malcolm soils have the profile described as representative of the series. The Morrill and Mayberry soils in this complex have profiles similar to the ones described as representative of their respective series, but the underlying material is stratified silt loam, loam, and very fine sandy loam.

The small slickspots are mainly clayey, strongly alkaline soil material that is plastic and very sticky when wet and very hard when dry. These slickspots are difficult to work. Native vegetation is sparse. The small sandy and gravelly areas are reworked glacial material that has been exposed at the surface.

Water erosion is the principal hazard on these soils. Runoff is rapid. A few of the drainageways are gullied.

Most areas of this complex are in native grass. These soils are best suited to this use. Slopes are uneven and are generally too steep for successful cultivation. Capability unit VIe-1; Silty range site; windbreak suitability group 4.

Mayberry Series

The Mayberry series consists of deep, moderately well drained soils on uplands (fig. 10). These soils



Figure 10.—Profile of Mayberry loam. This soil formed in reworked glacial deposits.

formed in material reworked from glacial deposits. They are gently to strongly sloping.

In a representative profile the surface layer is about 13 inches thick. The upper part is black loam and the lower part is very dark brown clay loam. The subsoil is mottled clay extending to a depth of 60 inches. It is dark reddish brown and firm in the upper part, dark reddish brown and very firm in the middle part, and reddish brown and very firm in the lower part.

Permeability is slow, and available water capacity is moderate. Natural fertility is high. The surface layer is medium acid. Moisture is released slowly to plants.

These soils are suited to cultivated crops, grasses, and trees in windbreaks. They are used as habitat by some kinds of wildlife. They have limited potential for recreational use.

Representative profile of Mayberry loam, 3 to 9 percent slopes, in a native grass meadow 400 feet west and 150 feet north of the southeast corner of sec. 21, T. 3 N., R. 12 E.:

- A11—0 to 6 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) dry; moderate, very fine, granular structure; slightly hard, friable; medium acid; clear, smooth boundary.
- A12—6 to 13 inches, very dark brown (10YR 2/2) clay loam, very dark grayish brown (10YR 3/2) dry; moderate, fine and medium, granular structure; hard, friable; medium acid; gradual, smooth boundary.
- B1t—13 to 24 inches, dark reddish-brown (5YR 3/3) light clay, reddish brown (5YR 4/3) dry; many, faint, very dark grayish-brown (10YR 3/2) mottles; strong, very fine, blocky structure; very hard, firm; thin, dark coatings on faces of peds; slightly acid; gradual, smooth boundary.
- B21t—24 to 48 inches, dark reddish-brown (5YR 3/4) clay, reddish brown (5YR 4/3) dry; common, prominent, black (5YR 2/1) mottles; moderate, medium and fine, blocky structure; extremely hard, very firm; small, reddish iron-manganese concretions; dark coatings on faces of peds; slightly acid; gradual, smooth boundary.
- B22t—48 to 60 inches, reddish-brown (5YR 4/4) clay, reddish brown (5YR 5/4) dry; common, distinct, dark grayish-brown (10YR 4/2) mottles; moderate, medium, blocky structure; extremely hard, very firm; continuous coatings on faces of peds; neutral.

The A horizon ranges from 4 to 16 inches in thickness. It ranges from loam to clay in texture and from black to dark reddish brown in color. The B horizon ranges from silty clay to sandy clay in texture and from dark reddish brown to reddish brown to dark brown in color. In places the B22 horizon is yellowish brown. In places the B horizon contains bands of dissimilar material that ranges from very silty to very gritty. If the C horizon is at a depth of less than 60 inches, it is clayey to sandy material. Otherwise, it is not considered part of the soil profile. Stones are on the surface of this soil in places.

The surface layer of Mayberry soils, 3 to 9 percent slopes, severely eroded, is thinner and lighter colored than defined for the Mayberry series.

Mayberry soils occur in the landscape with Malcolm, Morrill, Pawnee, and Wymore soils. Mayberry soils have a finer textured, redder B horizon than Malcolm soils. They have a finer textured B horizon than Morrill soils, and they have a thicker, redder B horizon than Pawnee soils. Mayberry soils formed in reworked glacial deposits, and Wymore soils formed in loess.

Mayberry loam, 3 to 9 percent slopes (MdC).—This soil is in areas bordering the sides of valleys. It is mostly on south- and east-facing slopes along major

creeks. In places, this soil is near or below the ends of upland ridges.

This soil has the profile described as representative of the series. Included with this soil in mapping were small areas of Malcolm and Pawnee soils. In places, the surface layer is silt loam or silty clay loam. The subsoil contains bands of silty material and gritty material in places. A few areas have underlying grayish interglacial deposits similar to those beneath Malcolm soils. Other areas have a substratum of glacial material similar to the material beneath Pawnee soils. In places, small slickspots were included in mapping.

Water erosion is the principal hazard on this soil. The dense clay subsoil is slowly permeable and is extremely hard when dry. During wet periods it dries slowly. Runoff is medium to rapid, depending on the amount of plant cover and degree of moisture saturation in the soil. Maintaining fertility is a concern of management.

About 75 percent of the acreage of this soil is cultivated. Wheat, grain sorghum, corn, clover, and alfalfa are the principal crops. About 25 percent of the acreage is in grass. Some managers prefer to keep these areas in grass because they are small and, in places, are adjacent to other soils that are not so well suited to cultivation. Capability unit IIIe-2; Clayey range site; windbreak suitability group 9.

Mayberry clay loam, 3 to 9 percent slopes, eroded (McC2).—This soil is in irregularly shaped areas that occur intermittently on smooth, south- and east-facing areas bordering major creeks and drainageways.

This soil has a profile similar to the one described as representative of the series, but the surface layer is clay loam. Erosion has removed most of the upper layer. The present surface layer is 5 to 9 inches thick. It is very dark brown or very dark grayish brown. In places, tillage has exposed the dark reddish-brown clay subsoil. Included with this soil in mapping were small areas of Pawnee and Malcolm soils, and a few slickspots.

Water erosion is the principal hazard on this soil. The content of nitrogen, phosphorus, and organic matter is generally low. Fertility needs to be improved and maintained. Runoff is rapid, and surface water needs to be conserved. The firm clay loam surface layer makes this soil fairly difficult to work.

Almost all of this acreage is cultivated or has been cultivated in past years. A few areas are in tame or native grass and are used for grazing livestock. Some tracts are not cultivated because they are too small or are adjacent to soils less suited to tillage. Capability unit IIIe-2, Clayey range site; windbreak suitability group 9.

Mayberry soils, 3 to 9 percent slopes, severely eroded (MfC3).—These soils are on hillsides bordering drainageways. They have a profile similar to the one described as representative of the series, but the surface layer is thinner and lighter colored. The surface layer is clay loam, silty clay, or clay. The present plow layer is only 4 to 6 inches thick. Erosion has removed nearly all of the original surface layer. Tillage has mixed the underlying subsoil with the remaining original surface layer.

Included with these soils in mapping were small areas of severely eroded Pawnee soils, slickspots, and small areas of soils having an underlying layer of stratified, silty and loamy material similar to that beneath Malcolm soils.

Water erosion is a serious hazard on this soil. The content of organic matter, nitrogen, and phosphorus are low. The poor tilth makes this soil difficult to till. The surface layer takes in moisture slowly and releases it to plants slowly. Runoff is rapid and surface water needs to be conserved. The included slickspots are strongly alkaline, and plant growth is poor on them. The clay in this soil swells when wet and shrinks when dry.

Most areas of this soil are used for cultivated crops, such as alfalfa, clover, and wheat. Because they are so difficult to work, many areas have been seeded to native or tame grasses and are used as range. A few areas are idle or are used as habitat for wildlife. Capability unit IVE-4; Dense Clay range site; windbreak suitability group 9.

Morrill Series

The Morrill series consists of deep, well-drained soils that formed in material reworked from glacial till on uplands (fig. 11). These soils are gently sloping to moderately steep.

In a representative profile the surface layer is very dark brown loam about 12 inches thick. The subsoil is about 28 inches thick. The upper part is dark-brown, friable clay loam that has a gritty feel. The middle part is reddish-brown, friable, gritty clay loam. The lower part is reddish-brown, friable sandy clay loam. The underlying material, at a depth of 40 to 60 inches, is strong-brown sandy loam.

Permeability is moderately slow, and available water capacity is high. The surface layer is medium acid. Natural fertility is medium.

Morrill soils are suited to cultivated crops, grasses, and trees in windbreaks. They can be used as wildlife habitat, and they have limited potential for use as recreation areas.

Representative profile of Morrill loam, 5 to 12 percent slopes, in a pasture 420 feet west and 50 feet south of the northeast corner of the SE $\frac{1}{4}$, sec. 28, T. 2 N., R. 12 E.:

- A—0 to 12 inches, very dark brown (10YR 2/2) loam, dark grayish brown (10YR 3.4/2) dry; weak, coarse, prismatic structure parting to moderate, fine, granular; slightly hard, very friable; medium acid; clear, smooth boundary.
- B1t—12 to 20 inches, dark-brown (7.5YR 3/2) clay loam; brown (7.5YR 5/2) dry; weak, coarse, prismatic structure parting to weak, very fine and fine, sub-angular blocky; slightly hard, friable; thin coatings on faces of peds; medium acid; clear, smooth boundary.
- B2t—20 to 30 inches, reddish-brown (5YR 4/4) clay loam; reddish brown (5YR 5/3.5) dry; weak, fine and medium, subangular blocky structure; hard, friable; thin coatings on faces of peds; medium acid; clear, smooth boundary.
- IIB3—30 to 40 inches, reddish-brown (5YR 4/4) sandy clay loam; reddish brown (5YR 5/4) dry; weak, medium and coarse, blocky structure; slightly hard, friable; slightly acid; abrupt, smooth boundary.



Figure 11.—Profile of Morrill loam. This soil formed in reworked glacial till.

IIC—40 to 60 inches, strong-brown (7.5YR 5/6) sandy loam, reddish yellow (7.5YR 6/6) dry; single grained; slightly hard, very friable; about 15 percent stones larger than 3 inches; slightly acid.

The A horizon ranges from 6 to 14 inches in thickness. It ranges from clay loam to sandy loam. Color ranges from very dark brown in soils that are not eroded to dark brown or dark reddish brown in severely eroded soils. The A horizon is medium acid or slightly acid. The B horizon ranges from 15 to 45 inches in thickness. It is dark brown to reddish brown loam, gravelly clay loam, or fine clay loam. The B horizon is medium acid to slightly acid. In places, the subsoil and C horizon contain bands of silty material or material that contains considerable medium sand. Stones are on the surface in places.

Morrill soils, 5 to 12 percent slopes, severely eroded, and Morrill soils, 12 to 17 percent slopes, severely eroded, have an A horizon that is thinner and lighter colored than defined for the series.

Morrill soils occur in the landscape with Mayberry, Malcolm, Shelby, and Burchard soils. Morrill soils are not so fine textured in the B horizon as Mayberry soils. They have a redder B horizon than the Malcolm soils. The B2 horizon of Morrill soils is similar to that of Shelby and Burchard soils, but it is redder and more acid.

Morrill loam, 3 to 5 percent slopes (MrC).—This soil is in widely separated areas on upland ridgetops. This soil has a profile similar to the one described as representative of the series, but the surface layer is slightly thicker.

Included with this soil in mapping were small areas of sandy and gravelly soils and tracts of Mayberry soils. Also included were small areas of soil having layered bands of various material, ranging from gravel to clay, in the subsoil or underlying material.

Water erosion is the principal hazard on this soil. Runoff is medium. This soil has good tilth and absorbs water readily. It is easily worked. Maintaining fertility is a concern of management.

About one-third of the acreage of this soil is cultivated, and all the crops commonly grown in the county are suited to this soil. The rest of the acreage is in grass and is used for grazing livestock. Capability unit IIe-1; Silty range site; windbreak suitability group 4.

Morrill loam, 5 to 12 percent slopes (MrD).—This soil is in low, irregularly shaped areas along major drainageways in the county.

This soil has the profile described as representative of the series. Included with this soil in mapping were about 10 percent Mayberry soils and about 10 percent deep soils that formed in sandy material. A few small areas of Malcolm soils are also included. In places, gravel crops out at the surface.

Water erosion is the principal hazard on this soil. This soil is fairly productive and responds well to good management. Water, air, and roots penetrate this soil easily. Moisture is stored well and released readily to plants.

About one-half of the acreage of this soil is used for cultivated crops. The rest is in grass and is used for grazing livestock. Capability unit IIIe-1; Silty range site; windbreak suitability group 4.

Morrill loam, 12 to 17 percent slopes (MrE).—This soil is in separated areas on hillsides along the larger streams in the county.

This soil has a profile similar to the one described as representative of the series, but the subsoil is slightly thinner. Included with this soil in mapping were small areas of Mayberry and Malcolm soils and areas of deep, sandy soils. In places, gravel crops out at the surface.

Water erosion is the principal hazard on this soil. The slopes make this soil somewhat difficult to till. Runoff is rapid and the surface water needs to be impounded and conserved. Maintaining fertility is a concern of management. This soil is friable.

Most of this acreage is in native grass, but a few areas are cultivated. Alfalfa, clover, and wheat are the crops most commonly grown on this soil. Capability unit IVe-1; Silty range site; windbreak suitability group 4.

Morrill soils, 5 to 12 percent slopes, severely eroded (MsD3).—These soils are in separated areas on the lower sides of the valleys that border the major drainageways. They have a profile similar to the one described as representative of the series, but the surface layer is thinner and lighter colored. The surface layer ranges widely in texture through loam, gravelly loam, sandy loam, and clay loam. In places, enough medium

and fine sand is mixed with the clay loam to give the soil a gritty feel.

Most of the original surface layer has been removed through water erosion. In most places, tillage has mixed the subsoil with the remaining original surface layer. The present surface layer is dark reddish brown.

Included with these soils in mapping were small areas of Morrill loam, 5 to 12 percent slopes, and small pockets of sand and gravel.

Water erosion is a serious hazard on these soils. Runoff is rapid and surface water needs to be conserved. The content of organic matter and nitrogen are low. These soils are fairly easy to work and they respond well to good management. Improvement of fertility is an important concern of management.

This acreage is used for cultivated crops and native and tame grasses. Other areas are idle or are used as wildlife habitat. Capability unit IVe-8; Silty range site; windbreak suitability group 4.

Morrill soils, 12 to 17 percent slopes, severely eroded (MsE3).—These soils are on hillsides adjacent to the major creeks in the county.

These soils have a profile similar to the one described as representative of the series, but the surface layer is thinner and lighter colored and ranges from loam and clay loam to sandy clay loam in texture. Most of the original surface layer has been removed by water erosion. Tillage has brought some of the subsoil to the surface and incorporated it with the remaining part of the original surface layer.

Included with these soils in mapping were small areas of Morrill loam, 12 to 17 percent slopes, and small pockets of mixed sand and gravel. Water erosion is a severe hazard on this soil. The content of organic matter and nitrogen are low. Tilth is fair. This soil is fairly easy to till, but the moderately steep slopes restrict the use of large machinery. Runoff is rapid and conservation of surface water is an important concern of management.

Most of this acreage is in native or tame grass. The soils are too steep and too eroded for successful cultivation. A few small areas are used as hayland and a few are used as wildlife habitat. Capability unit VIe-8; Silty range site; windbreak suitability group 4.

Pawnee Series

The Pawnee series consists of deep, moderately well drained soils on uplands (fig. 12). These soils formed in weathered glacial till. They are nearly level to strongly sloping.

In a representative profile the surface layer is about 10 inches thick. The upper part is very dark brown loam and the lower part is very dark brown clay loam. The next layer is dark-brown clay loam about 4 inches thick. The subsoil is about 39 inches of mottled, very firm clay. It is dark yellowish brown in the upper part and olive brown, grayish brown, and yellowish brown in the lower part. The underlying material is between the depths of 53 and 60 inches. It is grayish-brown clay loam.

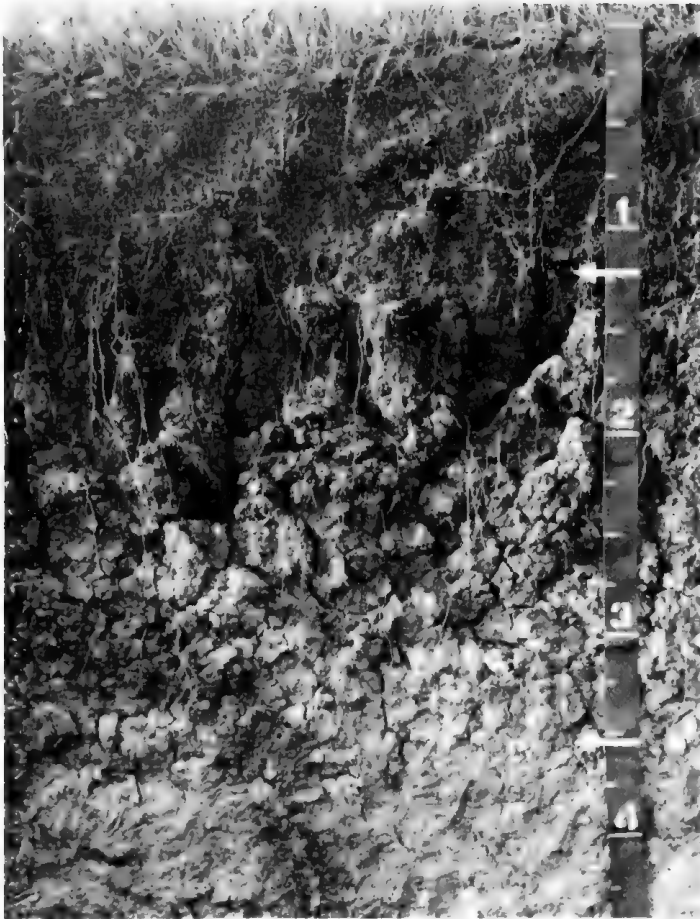


Figure 12.—Profile of Pawnee loam. This soil formed in material weathered from glacial till. It has a clay subsoil.

Permeability is slow, and available water capacity is moderate. Natural fertility is high. The surface layer is medium acid.

Pawnee soils are suited to cultivated crops where slopes are not too steep. They are also suited to grasses and trees. These soils can be used as areas for some forms of recreation and as wildlife habitat.

Representative profile of Pawnee loam, 3 to 9 percent slopes, in a cultivated field 0.3 mile west and 350 feet south of the northeast corner of sec. 2, T. 2 N., R. 11 E.:

- Ap—0 to 6 inches, very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; moderate, fine and very fine, granular structure; slightly hard, friable; medium acid; abrupt, smooth boundary.
- A12—6 to 10 inches, very dark brown (10YR 2/2) clay loam, very dark grayish brown (10YR 3/2) dry; moderate, medium, granular structure; slightly hard, friable; medium acid; clear, smooth boundary.
- AB—10 to 14 inches, dark-brown (10YR 3/3) clay loam, dark yellowish brown (10YR 3/4) dry; few, fine prominent, dark reddish-brown (5YR 3/4) mottles; moderate, medium and fine, blocky structure; hard, friable; medium acid; gradual, smooth boundary.
- B21t—14 to 24 inches, dark yellowish-brown (10YR 3/4) clay, dark yellowish brown (10YR 3/4) dry; few, fine, medium, reddish-brown (5YR 4/4) mottles;

moderate, coarse and medium, blocky structure; extremely hard, very firm; thin, continuous coatings on faces of peds; few pebbles; slightly acid; gradual, smooth boundary.

- B22t—24 to 32 inches, dark yellowish-brown (10YR 4/4) clay, brown (10YR 4/3) dry; common, medium, grayish-brown (10YR 5/2), strong-brown (7.5YR 5/6), and reddish-brown (5YR 5/4) mottles; weak, coarse, blocky structure; extremely hard, very firm; thin, continuous coatings on faces of peds; few pebbles; neutral; gradual, smooth boundary.

- B23t—32 to 45 inches, olive-brown (2.5Y 4/4) clay, light olive brown (2.5Y 5/4) dry; many, medium, distinct, grayish-brown (10YR 5/2) and brown (7.5YR 5/4) mottles; weak, coarse, blocky structure; very hard, very firm; patchy, thin coatings on faces of peds; moderately alkaline; gradual, smooth boundary.

- B3—45 to 53 inches, mixed grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/6) light clay, light olive brown (2.5Y 5/4) and dark yellowish brown (10YR 4/8) dry; many, medium, diffuse, dark-brown (7.5YR 4/4) mottles; weak, medium, blocky structure; very hard, very firm; few medium lime concretions; moderately alkaline; clear, smooth boundary.

- C—53 to 60 inches, grayish-brown (2.5Y 5/2) clay loam, light olive brown (2.5Y 5/4) dry; many, coarse, diffuse, grayish-brown (10YR 5/2) mottles; moderate, medium and coarse, blocky structure; hard, firm; small iron and manganese concretions; strong effervescence; few, medium and large, soft lime segregations; moderately alkaline.

The A horizon ranges from 4 to 14 inches in thickness. It ranges from loam and silt loam to clay in texture and from black to very dark grayish brown in color. This horizon is medium acid or slightly acid. The B horizon ranges from 25 to 55 inches in thickness. It ranges from dark brown and dark yellowish brown to yellowish brown and light olive brown. Mottles are commonly reddish in the upper part of the B horizon and yellowish or grayish in the lower part. Depth to lime ranges from 40 to 70 inches. Pawnee soils commonly have a few stones and boulders on the surface.

Pawnee soils, 3 to 9 percent slopes, severely eroded, and Pawnee and Mayberry soils, 9 to 12 percent slopes, severely eroded, have an A horizon that is thinner and lighter colored than defined for the series.

Pawnee soils are associated in the landscape with Burchard, Shelby, Mayberry, and Wymore soils. Pawnee soils have a finer textured B horizon and have lime deeper in the profile than Burchard or Shelby soils. The B horizon of Pawnee soils is not so red as that of Mayberry soils. Pawnee soils formed in material weathered from glacial till, and Wymore soils formed in material weathered from loess.

Pawnee loam, 0 to 3 percent slopes (PaB).—This soil is in small, narrow tracts on upland ridgetops.

This soil has a profile similar to the one described as representative of the series, but the surface layer is slightly thicker. Included with this soil in mapping were small areas of Mayberry and Wymore soils.

The slow permeability of the clayey, very firm subsoil is the principal limitation of this soil. Runoff is slow. The surface layer is friable, but it dries slowly because movement of moisture through the subsoil is slow. Tillage is commonly delayed by wetness. Maintaining fertility is a concern of management. Erosion is a minor hazard.

About one-half of the acreage of this soil is cultivated and the rest is in native or tame grasses. This soil is productive. Capability unit IIs-2; Clayey range site; windbreak suitability group 9.

Pawnee loam, 3 to 9 percent slopes (PaC).—This soil is in irregularly shaped tracts on ridgetops and hillsides.

This soil has the profile described as representative of the series. Included with this soil in mapping were small areas of Mayberry, Wymore, and Shelby soils.

Water erosion is the principal hazard if this soil is cultivated. Runoff is medium, and surface water needs to be conserved. Because the dense clay subsoil is slowly permeable to water, this soil dries slowly during wet periods. Maintaining fertility is a concern of management.

About 75 percent of this soil is in grasses, and the rest is cultivated. Crops, such as wheat, grain sorghum, corn, and clover are suited to this soil. Some farmers choose to keep the soil in grasses because the tracts are too small or too irregular in shape for cultivation or are adjacent to soils that are less suitable for tillage. Capability unit IIIe-2; Clayey range site; windbreak suitability group 9.

Pawnee clay loam, 3 to 9 percent slopes, eroded (PnC2).—This soil is in irregularly shaped tracts on ridges and on the upper parts of hillsides.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner and finer textured. The surface layer is about 6 to 9 inches of clay loam. Much of the original surface layer has been removed through water erosion. In places, tillage has brought the upper part of the subsoil to the surface. Included with this soil in mapping were small areas of Mayberry, Wymore, and Shelby soils.

Water erosion is a severe hazard on this soil. Runoff is medium to rapid, depending on the amount of plant cover. Surface water needs to be conserved. The content of organic matter is medium. The clay subsoil releases moisture slowly during dry periods. Fertility needs to be improved.

Almost all of the acreage of this soil is cultivated or has been cultivated. Some areas have been seeded to grasses and are used as pasture or range. Such crops as alfalfa, clover, and wheat are suited to this soil. Row crops are also grown. Capability unit IIIe-2; Clayey range site; windbreak suitability group 9.

Pawnee soils, 3 to 9 percent slopes, severely eroded (PsC3).—These soils are in irregularly shaped areas on ridge-tops and upper parts of hillsides.

These soils have a profile similar to the one described as representative of the series, but the surface layer is thinner, lighter colored, and finer textured. Water erosion has removed most or all of the original surface layer. The present surface layer is 4 to 7 inches of very dark grayish-brown and dark grayish-brown clay and heavy clay loam. In most places, a few pebbles and large stones remain on the soil surface where the finer material has been washed away.

Included with these soils in mapping were a few areas of Pawnee clay loam, 3 to 9 percent slopes, eroded, next to drainageways or in swales. Also included were a few small areas of Shelby soils and severely eroded Mayberry soils.

These soils are not well suited to cultivated crops because of the poor tilth, the dense clay subsoil, and the severe hazard of erosion.

Water erosion is the main hazard on these soils. These soils have poor tilth and are difficult to work. Runoff is medium to rapid, depending on the amount of plant cover. Surface water needs to be conserved. The content of organic matter and nitrogen are low. Improvement of fertility is an important concern of management.

These soils are marginal for cultivated crops, but a few areas are cultivated. Alfalfa, clover, and wheat are the commonly grown crops. Most areas have been seeded to cool-season tame grasses or warm-season native grasses. A few areas are idle. Capability unit IVE-4; Dense Clay range site; windbreak suitability group 9.

Pawnee and Mayberry soils, 9 to 12 percent slopes, severely eroded (PwD3).—These soils occur mainly as small, narrow areas of short slopes bordering upland drainageways. Some areas are made up entirely of Pawnee soils and others are entirely Mayberry soils, but most are made up of both soils.

Each of the soils in this mapping unit has a profile similar to the one described as representative of its respective series, but the surface layer is thinner, lighter colored, and finer textured. Water erosion has removed most of the original surface layer. The present surface layer is 4 to 7 inches of dark grayish-brown or very dark grayish-brown clay, clay loam, or silty clay loam. Included areas of Wymore soils make up as much as 30 percent of some areas.

Water erosion is a very severe hazard on these soils. Runoff is rapid and is accelerated where vegetation is sparse. Moisture enters the soils slowly. These soils have poor tilth and are difficult to work. Content of organic matter and nitrogen are low. In overgrazed pastures, cattle paths and erosion expose the subsoil. Moisture is released slowly to plants.

These soils are not well suited to cultivated crops. They have strong slopes, poor tilth, rapid runoff, and a severe hazard of erosion. These soils are best suited to native perennial grasses for use as range, as wildlife habitat, and for hay. Only a few areas are cultivated. Capability unit VIe-4; Dense Clay range site; windbreak suitability group 9.

Rough Broken and Gullied Land

Rough broken and gullied land (30 to 60 percent slopes) (Rg) is in irregular, narrow strips on uplands. This land type is made up of stabilized, short slopes along the sides of drainageways and of nearly vertical, almost barren, gullied drainage channels. The areas range from 50 to 300 feet in width. The soil material is deep and excessively drained.

Soil material varies greatly. In places, it is loess, glacial deposits, alluvium, or various kinds of geologic sediment. In other places it is mixed materials that have fallen or washed down from higher areas. The stabilized, short, very steep slopes are mostly clayey material, but in places they contain layers of material of varying texture that feels distinctly gritty.

Permeability is mostly moderately slow, and available water capacity is high or moderate.

Water erosion is the principal hazard on areas of this land type. The very steep slopes, lack of plant cover, and clayey materials cause runoff to be very rapid. These soils are difficult to work and in most places are too steep to shape into grassed waterways.

Rough broken and gullied land is used almost entirely for grazing livestock or as native woodland. These areas are good habitat for many kinds of upland wildlife. They support sparse grass and trees. Some areas are brushy, and a few are almost barren. Capability unit VIIe-7; Silty range site; windbreak suitability group 10.

Shelby Series

The Shelby series consists of deep, moderately well drained soils on uplands. These soils formed in material weathered from limy glacial till (fig. 13). They

transitional layer between the surface layer and the subsoil is very dark grayish-brown clay loam about 6 inches thick. The subsoil is clay loam about 32 inches thick. The upper part is dark brown and friable. The middle part is dark yellowish brown and firm. The lower part is yellowish brown and firm and contains many lime concretions. The underlying material is yellowish-brown clay loam between depths of 50 and 60 inches. It contains channels and pockets of soft lime. The underlying material is the glacial till in which Shelby soils formed.

Permeability is moderately slow, and available water capacity is high. Natural fertility is high. The surface layer is medium acid. Water is released readily to plants.

Shelby soils are suited to cultivation in areas where slopes are not too steep. They are also suited to grasses and to trees in windbreaks. Shelby soils can be used as wildlife habitat and as recreation areas.

Representative profile of Shelby clay loam, 5 to 12 percent slopes, in an area of native grasses 0.2 mile west and 200 feet north of the southeast corner of sec. 28, T. 1 N., R. 10 E.:

- A—0 to 12 inches, very dark brown (10YR 2/2) light clay loam, very dark gray (10YR 3/1) dry; moderate, very fine and fine, granular structure; slightly hard, friable; medium acid; gradual, smooth boundary.
- AB—12 to 18 inches, very dark grayish-brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) dry; strong, fine and medium, granular structure; slightly hard, friable; medium acid; gradual, smooth boundary.
- B2t—18 to 28 inches, dark-brown (10YR 4/3) clay loam, brown (10YR 5/3) dry; weak, coarse, prismatic structure parting to strong, very fine and fine, sub-angular blocky; hard, friable; thin coatings on faces of peds; slightly acid; gradual, smooth boundary.
- B22t—28 to 39 inches, dark yellowish-brown (10YR 4/4) clay loam, yellowish brown (10YR 5/4) dry; few, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine and medium, blocky structure; hard, firm; thin, continuous coatings on faces of peds; slightly acid; clear, wavy boundary.
- B3—39 to 50 inches, yellowish-brown (10YR 5/4) clay loam, pale brown (10YR 6/3) dry; many, yellowish-brown (10YR 5/6), grayish-brown (10YR 5/2), and black (10YR 2/2) mottles; weak, medium and coarse, blocky structure; hard, firm; many lime concretions; strong effervescence; moderately alkaline; gradual, smooth boundary.
- C—50 to 60 inches, yellowish-brown (10YR 5/6) clay loam, light yellowish brown (10YR 6/4) dry; weak, coarse, blocky structure; hard, firm; strong effervescence; many channels and small pockets of soft lime; moderately alkaline.

The A horizon ranges from 7 to 20 inches in thickness and from black to very dark grayish brown in color. The B horizon ranges from 20 to 40 inches in thickness and from clay loam to light clay in texture. Depth to lime ranges from about 30 to 50 inches. A few stones and boulders are on the surface.

Shelby soils occur in the landscape with Burchard, Steinauer, and Pawnee soils. Shelby soils have lime lower in the profile than Burchard soils. They have a thicker A horizon than Steinauer soils, and they have a B horizon, which is lacking in Steinauer soils. Shelby soils have less clay in the B horizon than Pawnee soils.

Shelby clay loam, 5 to 12 percent slopes (SbD).—This soil is in irregularly shaped areas on the lower



Figure 13.—Profile of Shelby clay loam. This soil formed in limy glacial till.

are moderately sloping to moderately steep.

In a representative profile the surface layer is very dark brown light clay loam about 12 inches thick. A

parts of hillsides on the uplands of the Turkey Creek, Wolf Creek, and Plum Creek drainage areas.

This soil has the profile described as representative of the series. Included with this soil in mapping were a few areas that are as much as 20 percent Burchard soils. Also included were small areas of a soil that has pockets and thin layers of sandy material below a depth of 40 inches.

Water erosion is the principal hazard on this soil. Runoff is medium to rapid, depending on the vegetative cover. The soil is friable and fairly easy to work. Surface water needs to be conserved. Water, air, and roots can penetrate the subsoil easily. Maintaining fertility is a concern of management.

About 65 percent of this acreage is in grass and 35 percent is cultivated. Wheat, alfalfa, and clover are the most commonly grown crops, but corn and grain sorghum are also grown.

Some farmers prefer to use this soil for grasses rather than cultivated crops because small areas of grasses are easier to manage than small cultivated areas, and because, in places, this soil is adjacent to soils that are not well suited to tillage. Capability unit IIIe-1; Silty range site; windbreak suitability group 4.

Shelby and Burchard clay loams, 12 to 17 percent slopes (SkE).—These soils are in small, irregularly shaped areas on hillsides along the valleys of Turkey Creek, Wolf Creek, and Plum Creek. Some areas are made up entirely of Shelby clay loam, others are entirely Burchard clay loam, and many areas are made up of both soils. Lime has been leached to a greater depth in the Shelby soil than in the Burchard soil.

These soils each have a profile that is similar to the one described as representative of their respective series, but the surface layer is slightly thinner. In places, small areas of loam or sandy loam were included in mapping.

Because of the moderately steep slopes, the hazard of erosion is severe. Because slopes limit the use of large machinery, these soils are difficult to cultivate. Runoff is rapid and surface water needs to be conserved. The surface layer is friable.

Most of this acreage is in native grasses. These soils can be safely cultivated, but they need a high level of management. Wheat, clover, and alfalfa are the most commonly grown crops, but the cultivated acreage is small. Capability unit IVe-1; Silty range site; windbreak suitability group 4.

Silty Alluvial Land

Silty alluvial land (Sy) is in narrow strips on bottom land along streams that are subject to overflow. These areas are dissected by meandering streams. The soil material is subject to change each time the streams overflow. It is mainly stratified, grayish-brown to very dark brown silt loam, loam, very fine sandy loam, and silty clay loam. In places, sandy or clayey sediment is present.

Permeability is moderate, and available water capacity is high. Natural fertility is high. Moisture is released readily to plants.

Flooding is a serious hazard, and these areas are normally flooded several times each year. This land type is commonly dissected by the crooked stream channels that are impassable to farm machinery. Cultivation is not practical.

Nearly all of this acreage is in grass or is wooded. Areas supporting woody shrubs and annual weeds are also common. These areas provide good cover and habitat for many kinds of wildlife. They have limited potential for use as recreation areas. Capability unit VIw-7; Silty Overflow range site; windbreak suitability group 10.

Sogn Series

The Sogn series consists of shallow, somewhat excessively drained soils on upland knolls and hillsides. These soils formed in material weathered from hard limestone bedrock (fig. 14). They are moderately steep



Figure 14.—Profile of Sogn silty clay loam, a shallow soil formed of material weathered from hard limestone.

to very steep. In Pawnee County, Sogn soils are mapped only with Kipson soils as part of a soil complex. The mapping unit is described under the Kipson series.

In a representative profile the surface layer is very dark brown silty clay loam about 8 inches thick. The few rock fragments in the surface layer increase in

size and number with depth. The level beds of underlying limestone have vertical joints and cracks in the upper part. These joints are filled with silty clay loam soil material. Beneath the broken rock is 18 inches of solid limestone bedrock. Between the depths of 36 inches and 60 inches is partly weathered limestone that has joints filled with light olive-brown silty and clayey shale.

Permeability of the surface layer is moderately slow. Available water capacity is very low. Natural fertility is low.

Sogn soils are not suitable for cultivation because they are too steep and too shallow and commonly have bedrock at the surface. They are well suited to native grasses. They are not suited to windbreak plantings. Wildlife use these soils as habitat. These areas can be used for some forms of recreation, such as hunting.

Representative profile of Sogn silty clay loam in an area of Kipson-Sogn complex 0.2 mile north and 50 feet east of the southwest corner of sec. 10, T. 2 N., R. 12 E.:

- A—0 to 8 inches, very dark brown (10YR 2/2) silty clay loam, very dark gray (10YR 3/1) dry; moderate, coarse, granular structure; hard, friable; neutral; few limestone fragments 1 to 3 inches thick and 3 to 6 inches long that increase in number and size near lower boundary; clear, wavy boundary.
- R1—8 to 18 inches, level-bedded limestone rocks 3 to 6 inches thick and 2 to 3 feet long; joints between rocks filled with very dark grayish-brown (10YR 3/2) silty shale; clear, smooth boundary.
- R2—18 to 36 inches, level-bedded limestone rocks 4 to 14 inches thick and 2 to 3 feet long; gradual, irregular boundary.
- R3—36 to 60 inches, limestone rocks 1 to 2 feet thick and 1 to 3 feet long; joints between rocks 4 to 8 inches thick filled with light olive-brown (2.5Y 5/4) silty and clayey shale.

The A horizon ranges from 5 to 18 inches in thickness and from black to dark brown in color. It contains few to numerous limestone fragments. The boundary between the A horizon and the bedrock ranges from abrupt to gradual and from smooth to irregular, depending on the density and consolidation of the limestone. Most of the bedrock is dense and hard, but it is somewhat rotten in places and can be broken or chipped, with some difficulty, with a spade. The consolidated layers range from 1 to 6 feet in thickness.

Sogn soils occur in the landscape with Kipson soils. Sogn soils formed in material weathered from limestone, and Kipson soils formed in material weathered from shale.

Steinauer Series

The Steinauer series consists of deep, well-drained soils on uplands. These soils formed in material weathered from glacial till (fig. 15). They are moderately sloping to steep.

In representative profile the surface layer is very dark grayish-brown clay loam about 4 inches thick. A layer of brown and dark grayish-brown clay loam about 5 inches thick is between the surface layer and the underlying material. The underlying material, extending to a depth of 60 inches, is light olive-brown clay loam. It is friable and has lime concretions and pockets of soft lime in the upper part. The lower part is firm and mottled.

Permeability is moderately slow and available water capacity is high. Natural fertility is medium. The sur-



Figure 15.—Profile of Steinauer clay loam. This soil formed in material weathered from glacial till.

face layer is moderately alkaline. Moisture is released readily to plants.

Where slopes are not too steep, Steinauer soils are suited to cultivated crops. They are also suited to grasses and to windbreak plantings. Wildlife use these areas as cover and habitat. These soils have limited potential for use as recreation areas.

Representative profile of Steinauer clay loam, 12 to 21 percent slopes, in an area of native grass 0.38 mile north and 125 feet east of the southwest corner of sec. 29, T. 3 N., R. 11 E.:

- A—0 to 4 inches, very dark grayish-brown (10YR 3/2) kneaded clay loam, dark gray (10YR 4/1) dry; moderate, medium and fine, subangular blocky structure parting to weak, fine, granular; slightly hard, friable; 5 percent material coarser than three-fourths inch; slight effervescence; moderately alkaline; clear, smooth boundary.
- AC—4 to 9 inches, brown (10YR 5/3) and very dark grayish-brown (10YR 3/2) clay loam, pale brown (10YR 6/3) and dark grayish brown (10YR 4/2) dry; moderate, medium and fine, subangular blocky structure; slightly hard, friable; mixed by worms; 5 percent material coarser than three-fourths inch; strong effervescence; moderately alkaline; clear, wavy boundary.
- C1—9 to 16 inches, light olive-brown (2.5Y 5/4) clay loam, pale yellow (2.5Y 7/4) dry; moderate, fine, subangular blocky structure; slightly hard, friable; 1 percent material coarser than three-fourths inch;

few worm casts; few small pockets of lime; few segregated lime concretions; strong effervescence; moderately alkaline; clear, wavy boundary.

C2—16 to 25 inches, light olive-brown (2.5Y 5/4) clay loam, pale yellow (2.5Y 7/4) dry; few, faint, brown (7.5YR 5/4) mottles; moderate, medium and fine, subangular blocky structure; hard, friable; about 2 percent material coarser than three-fourths inch; many large, soft pockets of lime; strong effervescence; moderately alkaline; clear, wavy boundary.

C3—25 to 60 inches, light olive-brown (2.5Y 5/4) kneaded fine clay loam, pale yellow (2.5Y 7/4) dry; few, distinct, light brownish-gray (2.5Y 6/2) and brown (7.5YR 5/4) mottles; brown and darker coatings (possibly of iron-manganese) on faces of peds in upper part; moderate, medium, blocky structure; very hard, firm; about 2 percent material coarser than three-fourths inch; occasional large, soft pockets of lime; few lime concretions; strong effervescence; moderately alkaline; gradual, wavy boundary.

The A horizon ranges from 3 to 6 inches in thickness and from very dark grayish brown to dark brown in color. The C horizon is mottled in colors ranging from dark yellowish brown to light olive brown and from grayish brown to light olive gray. In places it contains sandy layers.

Steinauer soils are associated in the landscape with Burchard, Shelby, and Pawnee soils. Steinauer soils have a thinner A horizon and lack the B horizon of all of these associated soils. They are neither so fine textured nor so acid as Pawnee soils.

Steinauer clay loam, 5 to 12 percent slopes (StD).—Widely separated areas of this soil are on knolls on the lower parts of hillsides bordering the tributaries and main valleys of Wolf Creek, Plum Creek, and Turkey Creek.

This soil has a profile similar to the one described as representative of the series, but the surface layer is slightly thicker. Pebbles and a few small stones are common on the surface. In cultivated areas, tillage has exposed the light-colored, limy underlying material and mixed it with the surface layer. Included with this soil in mapping were small areas of Burchard and Shelby soils.

Water erosion is the main hazard on this soil. Run-off is medium or rapid, depending on the amount and kind of vegetative cover. This soil is easy to work and takes moisture well, but, because it has a thin surface layer and is moderately to strongly sloping, it is only fair for crops. It responds well to a high level of management. The content of organic matter is low. Maintaining fertility is a concern of management.

Close-growing crops, such as alfalfa, clover, and wheat, are commonly grown on this soil. Grain sorghum, corn, and soybeans are also grown. Some farmers prefer to use this soil for grass, because it is easier to control runoff and erosion on soils in grass than on soils that are cultivated. In places, areas of this soil are small and are adjacent to soils that are not well suited to tillage. Capability unit IVe-9; Limy Upland range site; windbreak suitability group 5.

Steinauer clay loam, 12 to 21 percent slopes (StF).—This soil is on knolls and hillsides mainly along the valleys of Wolf Creek, Plum Creek, and Turkey Creek and their tributaries. Stones and small boulders are common on the surface.

This soil has the profile described as representative of the series. Included in mapping were small areas of Burchard and Shelby soils.

Erosion is a serious hazard on this soil because runoff is rapid on the moderately steep and steep slopes. This soil is not well suited to the use of heavy machinery. Surface water needs to be conserved. The content of organic matter, nitrogen, and phosphorus is low.

Most of the acreage of this soil is in native grass, and this soil is best suited to this use. A few small areas are in alfalfa and tame grasses. The soil is too steep and the surface layer is too thin for growing most cultivated crops. Capability unit VIe-9; Limy Upland range site; windbreak suitability group 5.

Wabash Series

The Wabash series consists of deep, poorly drained soils on bottom lands. These nearly level soils formed in material deposited by slack water.

In a representative profile the surface layer is 36 inches thick. The upper part is very dark brown and black silty clay loam. The lower part is black silty clay. A layer of very dark gray, very firm silty clay is between the surface layer and underlying material. The underlying material, between the depths of 44 and 60 inches, is very dark grayish-brown silty clay.

Permeability is slow, and available water capacity is moderate. Natural fertility is high. The surface layer is slightly acid. Wabash soils are subject to ponding during wet seasons. Moisture is released slowly to plants.

Wabash soils are suited to cultivated crops, grasses, and windbreak plantings. They are used by wildlife as habitat. They have limited potential for use as recreation areas.

Representative profile of Wabash silty clay loam, 500 feet east and 160 feet south of the center of sec. 21, T. 2 N., R. 11 E.:

Ap—0 to 7 inches, very dark brown (10YR 2/2) silty clay loam, very dark gray (10YR 3/1) dry; moderate, fine and very fine, granular structure; hard, friable; slightly acid; abrupt, smooth boundary.

A12—7 to 13 inches, black (2.5Y 2/0) silty clay loam, very dark gray (2.5Y 3/0) dry; moderate, fine, granular structure; hard, friable; slightly acid; gradual, smooth boundary.

A13—13 to 22 inches, black (10YR 2/1) silty clay, very dark gray (2.5Y 3/0) dry; moderate, fine, granular structure; hard, friable; slightly acid; gradual, smooth boundary.

A14—22 to 36 inches, black (10YR 2/1) silty clay, very dark gray (10YR 3/1) dry; moderate, medium and fine, blocky structure; shiny surfaces on vertical faces of peds; very hard, very firm; medium acid; gradual, smooth boundary.

AC—36 to 44 inches, very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; moderate, coarse, blocky structure; shiny surfaces on vertical faces of peds; very hard, very firm; slightly acid; gradual, smooth boundary.

C1g—44 to 52 inches, very dark grayish-brown (2.5Y 3/2) silty clay, dark gray (5Y 4/1) dry; moderate, coarse, blocky structure; shiny surfaces on vertical faces of peds; very hard, very firm; neutral; gradual, smooth boundary.

C2g—52 to 60 inches, very dark grayish-brown (2.5Y 3/2) silty clay, dark gray (5Y 4/1) dry; moderate, coarse, blocky structure; shiny surfaces on verti-

cal faces of peds; very hard, very firm; strong effervescence; mildly alkaline.

The A horizon ranges from silty clay loam to silty clay. The C horizon ranges from very dark gray to dark grayish brown in color. Olive to light olive-brown mottles are few to many. In places, lime concretions are present below a depth of 45 inches.

Wabash soils occur in the landscape with Colo and Kennebec soils. Wabash soils are finer textured than Colo and Kennebec soils, and they are more poorly drained.

Wabash silty clay loam (0 to 1 percent slopes) (Wa).—This soil is in broad areas mainly on bottom lands of the North Fork and South Fork of the Big Nemaha River and Turkey Creek. A few areas are in the valleys of Plum Creek and Wolf Creek.

This soil has the profile described as representative of the series. Included in mapping were areas of a soil that has fine olive mottles and small lime concretions in the underlying material.

This soil is well suited to cultivation, but the dense, silty clay subsurface layers, slow permeability, and low slope gradient cause it to dry slowly following rainy weather. Many areas need surface drainage. Maintaining fertility is a concern of management.

Most areas of this soil are used for cultivated crops. Grain sorghum and corn are the most commonly grown crops. A smaller acreage is used for growing wheat and soybeans, and only a few tracts are used for alfalfa, clover, and grasses. Capability unit IIIw-2; Clayey Overflow range site; windbreak suitability group 2.

Wabash silty clay (0 to 1 percent slopes) (Ws).—This soil is principally on the bottom land of the North Fork of the Big Nemaha River Valley. A few areas are on the bottom land along Turkey Creek.

This soil has a profile similar to the one described as representative of the series, but the upper part of the surface layer is silty clay. Included with this soil in mapping were areas that are about 20 percent Wabash silty clay loam. In places, small alkali slickspots and small seeped areas are included near the bases of upland slopes.

Wetness is the principal limitation to tillage. Surface drainage is needed. The slow runoff causes delays in tillage and planting following rains. The silty clay surface layer and firm consistency make this soil difficult to work. When rainfall is below average, preparing a good seedbed and obtaining a uniform stand is difficult. Maintaining fertility is a further concern of management.

Most areas of this soil are used for cultivated crops. Grain sorghum, wheat, soybeans, and legumes are the commonly grown crops. Legumes have a deep taproot system that helps to open this soil to air and moisture. A few areas of this soil are in native grass. Capability unit IIIw-1; Clayey Overflow range site; windbreak suitability group 2.

Wet Alluvial Land

Wet alluvial land (Wx) consists of deep, very poorly drained soils that occur in an intermittent pattern on bottom land. It is in narrow tracts along small drainageways adjacent to uplands and in small irregularly shaped tracts near the bases of upland slopes in

the larger stream valleys. Seepage water drains onto these areas from the adjacent uplands.

The soil material in this mapping unit is very dark brown, black, or very dark gray silt loam or silty clay loam in the upper part. The lower part is very dark gray silty clay loam or silty clay. The soil is generally neutral to mildly alkaline. In places, the subsurface layer and underlying material contain fragments of snail shells and small to large, hard concretions of lime. In some areas of bottom land near small drainageways, light-colored, recently deposited overwash that is as much as 30 inches thick overlies the original dark soil. Permeability varies from moderate to slow.

This land type is too wet to be cultivated and, in most areas, coarse grasses are the main vegetation. Many areas are used for hay or pasture. In the wettest areas, rushes, cattails, willows, and other marsh plants are common. Tracts adjacent to cultivated areas are excellent habitat for wetland wildlife. Capability unit Vw-7; Wet Land range site; windbreak suitability group 10.

Wymore Series

The Wymore series consists of deep, moderately well drained soils on uplands. These soils formed in grayish loess (fig. 16). They range from nearly level to gently sloping.

In a representative profile the surface layer is black silty clay loam about 13 inches thick. The subsoil is about 33 inches thick. The upper part is very dark brown, firm, light silty clay. The middle part is dark grayish-brown and grayish-brown, very firm silty clay. The lower part is olive-gray, firm, heavy silty clay loam. The underlying material, between the depths of 46 and 60 inches, is friable silty clay loam. It is olive gray in the upper part and dark grayish brown in the lower part. The soil is mottled beneath a depth of 19 inches.

Permeability is slow, and available water capacity is high. Natural fertility is high. The surface layer is medium acid. Moisture is released slowly to plants.

Wymore soils are suited to cultivated crops, to grasses, and to trees in windbreaks. They are used by wildlife as habitat and as a source of food. These soils can also be used as recreation areas.

Representative profile of Wymore silty clay loam, 3 to 7 percent slopes, in an area of native grasses 0.3 mile east and 150 feet south of the northwest corner of sec. 20, T.2 N., R. 10 E.:

- A—0 to 13 inches, black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate, fine, granular structure; hard, friable; medium acid; gradual, smooth boundary.
- B1t—13 to 19 inches, very dark brown (10YR 2/2) light silty clay, dark gray (10YR 4/1) dry; moderate, very fine, subangular blocky structure; hard, firm; patchy coatings on faces of peds; medium acid; clear, smooth boundary.
- B21t—19 to 32 inches, dark grayish-brown (10YR 4/2) silty clay, grayish brown (10YR 5/2) dry; common, fine, faint, strong-brown (10YR 5/6) mottles; moderate, medium, blocky structure; very hard, very firm; thin continuous coatings on faces of peds; slightly acid; gradual, smooth boundary.



Figure 16.—Profile of Wymore silty clay loam. This soil formed in loess, a wind-deposited material.

- B22t—32 to 40 inches, grayish-brown (2.5Y 5/2) silty clay, light brownish gray (2.5Y 6/2) dry; common, medium, distinct, brown (10YR 5/4) mottles and few black (10YR 2/1) mottles; moderate, medium and coarse, blocky structure; very hard, very firm; thin, continuous coatings on faces of peds; neutral; gradual, smooth boundary.
- B3—40 to 46 inches, olive-gray (5Y 5/2) heavy silty clay loam, light olive gray (5Y 6/2) dry; common, medium, distinct, strong-brown (10YR 5/6) mottles and few, fine, black (10YR 2/1) mottles; moderate, coarse, blocky structure; hard, firm; neutral; gradual, smooth boundary.
- C—46 to 55 inches, olive-gray (5Y 5/2) silty clay loam, light gray (5Y 7/2) dry; many, large, prominent, strong-brown (10YR 5/6) mottles; weak, coarse, blocky structure; hard, friable; neutral; clear, smooth boundary.
- A1b—55 to 60 inches, dark grayish-brown (10YR 4/2) silty clay loam, light brownish gray (10YR 6/2) dry; common, fine and medium, distinct, reddish-brown (2.5YR 4/4) mottles; weak, coarse, blocky structure; hard, friable; neutral.

The A horizon ranges from 4 to 15 inches in thickness. It ranges from silty clay loam to silty clay in texture and from black to very dark grayish brown in color. The A horizon is medium acid or slightly acid. The B horizon is mostly 30 inches thick, but ranges from 18 to 36 inches. It contains few to many, fine to coarse, and faint to promi-

nent mottles. The C horizon ranges in color from dark grayish brown to light olive gray. Buried soils are common below a depth of 40 inches. In places lime concretions are in the lower part of the B horizon or in the C horizon.

Wymore soils occur in the landscape with Butler, Crete, Mayberry, and Pawnee soils. Wymore, Butler, and Crete soils formed in similar material. Wymore soils, however, are better drained than Butler soils, and they lack the A2 horizon of Butler soils. Wymore soils have a lighter colored B21t horizon than Crete soils. Wymore soils formed in loess, and Mayberry and Pawnee soils formed in glacial till.

Wymore silty clay loam, 0 to 3 percent slopes (WyB).—This soil is on upland divides. A few areas are at lower elevations downslope from soils that formed in bedrock.

This soil has a profile similar to the one described as representative of the series, but the surface layer is a little thicker. Included with this soil in mapping were small areas of Crete and Butler soils.

Because of the clayey subsoil, this soil absorbs water slowly. This soil dries slowly following rains. Moisture is released slowly to plants. This soil is well suited to cultivated crops if proper tillage practices are used. Runoff is slow.

Nearly all the acreage of this soil is cultivated. Grain sorghum, wheat, and clover are the most commonly grown crops, but corn and soybeans are also grown. A small acreage is in grasses. Capability unit IIs-2; Clayey range site; windbreak suitability group 4.

Wymore silty clay loam, 3 to 7 percent slopes (WyC).—This soil is mainly on ridgetops, but a few areas are adjacent to natural drainageways.

This soil has the profile described as representative of the series. Included were a few small areas of eroded Wymore soils.

Water erosion is the principal hazard. Maintaining fertility is a concern of management if this soil is cultivated. Runoff is medium.

Nearly all the acreage of this soil is in grasses. This soil is suited to all crops commonly grown in the county. Capability unit IIIe-2; Clayey range site; windbreak suitability group 4.

Wymore silty clay loam, 3 to 7 percent slopes, eroded (WyC2).—This soil is on ridgetops and hillsides. This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner. The surface layer is only about 5 to 9 inches thick and has lost some of its original granular structure. In places, it has been somewhat compacted by tillage implements. Water erosion is active on this soil. In places, tillage has mixed parts of the upper subsoil with the remaining surface layer.

Water erosion is the principal hazard on this soil. This soil is productive, but it needs protection from erosion. The content of organic matter is medium. This soil is not so easy to work as the uneroded Wymore soils. Runoff is medium. During rainy periods, the soil dries slowly. Moisture is released slowly to plants during dry periods.

Most of the acreage of this soil is cultivated. Grain sorghum, wheat, and clover are the principal crops. Corn, soybeans, and alfalfa are also grown. Only a small acreage is in grasses. Capability unit IIIe-2; Clayey range site; windbreak suitability group 4.

Wymore soils, 3 to 7 percent slopes, severely eroded (WzC3).—These soils are in small areas, mainly on uplands bordering small drainageways.

These soils have a profile similar to the one described as representative of the series, but the surface layer and subsoil are thinner and lighter colored. Most of the original surface layer has been lost through erosion. The silty clay layer that was originally the subsoil is now at or near the surface. Tillage has mixed various amounts of the clayey subsoil with the thin remaining part of the original surface layer. The present plow layer is 4 to 6 inches thick and consists of very dark gray or very dark grayish-brown silty clay or heavy silty clay loam. Most of the original granular structure is gone, and the present structure is coarse blocky. The present subsoil is 18 to 26 inches of olive-gray silty clay. It is slowly permeable to water and air.

Included with these soils in mapping were small areas of soils having a dark grayish-brown subsoil. Also included were small areas of soils having very dark grayish-brown upper subsoils. In places, as much as 25 percent of the areas mapped is Wymore silty clay loam, 3 to 7 percent slopes, eroded.

Water erosion is the principal hazard. The poor tilth, dense clay subsoil, and severe hazard of erosion make these soils difficult to work. Workability is a concern of management because plowing extends into the clayey subsoil and the clay thereby exposed at the surface swells when wet and shrinks when dry. These soils are very hard when dry and very sticky and plastic when wet. Runoff is rapid.

Most of the acreage of the soil is used for growing cultivated crops such as wheat, clover, and alfalfa. A smaller acreage is used for growing row crops. A few areas are seeded to native or tame grasses, and a few areas are idle. Grasses respond well to good management. Capability unit IVE-4; Dense Clay range site; windbreak suitability group 4.

Use and Management of the Soils

This section provides information on the uses, management, and capabilities of the soils. The first brief section is concerned with management of tame pastures. The section on range management gives general information about the production of native grasses on range sites. The windbreak section discusses the suitability of the soils for windbreaks and lists trees that are suitable for each windbreak group. The section on wildlife lists those species of wildlife that are important in each soil association. Various soil properties significant to engineering, interpretations for engineering, and engineering test data are given in the section "Engineering Uses of the Soils."

Use of the Soils for Cropland

Crops on about 82,000 acres were harvested in Pawnee County in 1969. This cropland makes up nearly 30 percent of the total acreage of the county. The major crops are grain sorghum, corn, wheat, alfalfa, soybeans, and clover. Minor crops are oats, rye, forage sorghum, and forage crops used as pasture.

On cultivated soils, it is important to conserve moisture and control erosion and to maintain high fertility, good tilth, and the supply of organic matter. Only a few soils need drainage for maximum production of cultivated crops.

A cropping system consists of a sequence of crops grown on a given field over a period of years. The objectives are to maintain soil structure and good tilth, to protect the soils from erosion, and to control weeds, diseases, and insects. For most soils in the county, a good cropping sequence includes grasses, legumes, or other high-residue crops. The cropping system selected needs to fit the farm enterprise if a satisfactory economic return is to be expected.

Minimum tillage is a program that uses the minimum number of tillage operations to produce a crop. Plows and disk harrows are seldom used and are replaced by a tool that enters the soil and plants the seed without completely turning under the little from the preceding crop. Excessive tillage is costly, and it generally compacts the soil and breaks down soil structure. Minimum tillage is suitable for use on all of the soils in the county. It is more easily applied on the loamy soils, such as Kennebec, Judson, Morrill, Burchard, and Shelby soils, than on the more clayey soils, such as Wabash soils and the severely eroded Pawnee, Mayberry, and Wymore soils. Regardless of the type of tillage, soils need to be worked under the optimum content of soil moisture, and tillage operations need to be timed properly.

Crop residue protects the surface of the soil from the impact of raindrops, increases the capacity of the soil to take in moisture, and reduced the tendency of the soil to form a surface-sealing crust. Residue also adds organic matter that improves soil tilth and helps to maintain the supply of plant nutrients. The method of residue management used depends on the kind of soil, the cropping system, the amount of residue needed, the season, and the tilth and structure of the soil. If mulch tillage is used, crop residue remains on or near the surface throughout the year.

Contour farming consists of tilling and planting across the slope on the contour or parallel to terraces. The furrows and wheel tracks, then, do not vary in elevation. Terraces are ridges constructed across slopes to intercept runoff water from rainstorms. Part of the water is held in the terrace channels until it soaks into the soil. The excess water flows slowly into prepared sod waterways. The horizontal distance between terraces is determined by the steepness of slope and the kind of soil.

Grassed waterways are natural or constructed drainageways that carry runoff water from adjacent fields. They are protected by a permanent grass cover. A permanent grass cover is one of the best ways to control water erosion. The vegetative growth above the ground slows the water, and the fibrous roots bind the soil particles together and help to hold the soil in place. If grassed waterways are properly shaped, seeded, fertilized, and maintained, they can control gullying, produce good hay and grass seed, and furnish cover for upland game birds (fig. 17).



Figure 17.—A well-shaped and established grassed waterway on Wymore silty clay loam, 3 to 7 percent slopes, eroded.

Fertilizers are used to maintain a balanced supply of plant nutrients. Many soils in Pawnee County are high in natural fertility, but additional nutrients are sometimes needed, particularly when crops grow rapidly. Fertilizing is most effective when it is used in conjunction with other applicable management practices, such as residue management and contouring. The kind and amount of fertilizer needed are determined by testing. Most of the soils in the county need lime in order to produce high yields, especially high yields of alfalfa and clover. In 1969, about 6,960 tons of commercial fertilizer were used on about 56,000 acres in Pawnee County, and about 4,650 tons of lime were used on about 56,000 acres in Pawnee County, and about 4,650 tons of lime were used on 1,835. The increased use of nutrients by improved plant varieties and the ease of application of the nutrients have caused more commercial fertilizers to be used. Barnyard manure is also a good fertilizer, and it adds organic matter to the soil.

Drainage is a means of removing excess water in or on the soil. The method of drainage to be used depends on the kind of soil, the lay of the land, the slope, and the kind of water to be removed. Surface drainage can be improved by proper row direction of cultivated row crops, by land grading, and by surface bedding. Surface bedding is a series of alternating ridges and dead furrows formed by plowing. Tile drains can be used as interceptors for underground water tables and seepage areas.

Only a few soils in Pawnee County need a drainage system for cultivated crops. Drainage is generally not

desirable if the principal use of a soil is to be as wildlife habitat or recreation areas.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, the kinds of soils are grouped at three levels: the capability class, subclass, and unit. These levels are described in the following paragraphs:

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, or wildlife.

Class VI soils have severe limitations that make them generally unsuitable for cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuitable for cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife, water supply, or to use for esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass or kind of limitation as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

The name of the soil series and land types represented are mentioned in the description of each unit, but this does not mean that all the soils of a given series are in that unit. The capability unit designation

for each soil in the county can be found in the "Guide to Mapping Units."

In the following pages the capability units in Pawnee County are described and suggestions for the use and management of the soils are given.

Capability unit numbers are generally assigned locally, but are part of a statewide system. All of the units in the system are not represented by the soils of Pawnee County; therefore the numbers are not consecutive.

CAPABILITY UNIT Ie-1

Kennebec silt loam is the only soil in this capability unit. It is a deep, moderately well drained, nearly level soil on bottom lands. It is dominantly silt loam, but the lower part of the underlying material is loam.

This soil has moderate permeability and high available water capacity. It readily absorbs and releases moisture. Runoff is very slow. Natural fertility is high. This soil is easily worked and has good tilth. The surface layer is slightly acid.

This is a good soil for growing cultivated crops. The principal concern of management is the maintenance of fertility.

Corn and grain sorghum are the principal crops (fig. 18). Soybeans and winter wheat are also grown. All crops grown in the county are suited to this soil including clover, alfalfa, grasses, garden crops, and truck crops. Windbreak plantings are also suitable. Corn can be grown several years in succession, but control of weeds and plant diseases is needed for continued high production.

Proper use of crop residue helps to control surface crusting, and to prevent successive loss of soil moisture through evaporation. It also helps to increase the intake rate of water and to maintain soil structure, content of organic matter, and fertility.

CAPABILITY UNIT IIe-1

In this unit are very gently sloping to gently sloping soils of the Judson and Morrill series. These are deep, well-drained soils on uplands and foot slopes. They have a silt loam or loam surface layer and a silty clay loam or clay loam subsoil. The underlying material ranges from silty clay to sandy loam.

These soils have moderately slow permeability and high available water capacity. They readily absorb and release moisture. Runoff is slow to medium. Natural fertility is medium or high. The soils are easily worked and have good tilth. The surface layer is slightly acid or medium acid.

If not properly managed these soils are subject to damage through erosion. Maintaining fertility is a concern of management.

All the crops commonly grown in the county are suited to these soils. Corn and sorghum are the major crops. Minor crops are winter wheat, soybeans, red clover, and alfalfa. Also suited to these soils are garden crops, grasses, and windbreak plantings.

Corn can be grown several years in succession. Generally, a good cropping sequence, good management of crop residue, contour farming, terraces, and grassed waterways are needed for maintaining the soil and controlling erosion.



Figure 18.—Sorghum and corn growing on Kennebec silt loam, capability unit I-1.

Proper use of crop residue insures a high intake rate of water and helps to maintain the content of organic matter, the soil structure, and good soil tilth. Contour farming helps to control runoff and erosion. In places, terraces are needed as guides for contour farming and to protect the soils from erosion. Diversion terraces are needed in a few areas to protect Judson soils and adjacent bottom lands from concentrated runoff from nearby upland slopes. Field corners and borders seeded to grass provide turnaround areas for machinery and provide nesting places for upland game birds.

CAPABILITY UNIT IIa-2

In this unit are the nearly level Crete soils and the nearly level to very gently sloping Pawnee and Wyomere soils. These are deep, moderately well drained soils on uplands and stream terraces. The surface layer is silt loam, loam, or silty clay loam; the subsoil is silty clay or clay; and the underlying material is silty clay loam or clay loam.

These soils have slow permeability and moderate or high available water capacity. They slowly absorb and release moisture. Plant nutrients are retained well. Runoff is slow or very slow. The surface layer is medium acid or slightly acid.

The principal limitation is the clayey subsoil. During prolonged dry periods, these soils are somewhat droughty. The subsoil restricts the movement of air, water, and roots. The major concerns of management are the maintenance of the high fertility, the high content of organic matter, and the soil tilth. The soils are easily worked, but they dry somewhat slowly following rains.

Grain sorghum is the principal crop grown on these

soils. Corn, winter wheat, soybeans, red clover, and alfalfa are also grown. Crop selection is limited somewhat by the amount of moisture stored in these soils at planting time. Many farmers prefer grain sorghum because it can be planted late in spring and it can survive hot, dry periods during summer. Wheat planted during fall first uses moisture stored in the soil and then later uses the moisture of early spring rains. Also suited to these soils are grasses, trees, and shrubs for use as wildlife habitat.

Generally, row crops can be grown year after year without restriction. Management practices should include the use of minimum tillage, tilling the soils when not too wet, returning crop residue to the soil, and growing deep-rooted legumes to maintain soil structure. Tilling the soils when they are not too wet maintains good tilth. Contour farming on the very gently sloping soils helps to control runoff and erosion. Terraces can be used as guides for contour farming and as protection for soils that are downslope.

CAPABILITY UNIT IIw-2

Butler silt loam is the only soil in this unit. It is a deep, somewhat poorly drained, nearly level soil on uplands. The subsoil is silty clay, and the underlying material is silty clay loam.

This soil has slow permeability and high available water capacity. It slowly absorbs and releases moisture. Runoff is very slow. The soil is fertile and retains plant nutrients well. The clayey subsoil restricts movement of air and water. The surface layer is slightly acid.

This soil can be tilled only within a narrow range of moisture content. Cultivation, planting, and harvesting are commonly delayed by wetness following rains.

The principal concerns of management are providing for surface drainage, balancing plant nutrients, and maintaining soil structure and tilth. This soil is somewhat droughty during prolonged dry periods.

Many of the crops commonly grown in the county are suited to this soil, but grain sorghum and corn are the principal crops. Wheat, soybeans, red clover, and alfalfa are also grown. Legumes, especially alfalfa, open the clay subsoil and allow better penetration of moisture. Also suited to this soil are grasses and trees in windbreaks.

Using correct row direction, surface bedding, and land grading improve surface drainage. Using minimum tillage, managing crop residue, and tilling the soil when it is not too wet help to maintain the soil structure and the content of organic matter.

CAPABILITY UNIT IIw-3

Colo and Kennebec soils, occasionally flooded, are the only soils in this unit. These soils are deep, somewhat poorly drained and moderately well drained. They are nearly level soils on bottom lands.

These soils have moderately slow or moderate permeability and high available water capacity. Surface runoff is very slow. The soils are friable and easy to work. They readily absorb and release moisture. Natural fertility is high. The surface layer is slightly acid or neutral.

During spring, when they are occasionally flooded, these soils have a hazard of wetness. Small plants are subject to damage by deposits of silty material left by the floodwaters. These soils tend to be cold and to dry slowly in spring.

All the crops commonly grown in the county are suited to these soils, but corn and grain sorghum are the major crops. Small grains are not so well suited as most other crops because they tend to become rank and to lodge badly before harvest time. Garden crops, grasses, and windbreak plantings are also well suited to these soils. Odd-shaped areas are especially well suited to black walnut trees. Small areas in the corners of fields are used as wildlife habitat. Areas along smaller drainageways are suitable for constructing dugouts for use as a source of water for livestock.

Corn can be grown several years in succession. Using minimum tillage and properly managing crop residue help to maintain the content of organic matter and soil tilth. Flooding is best controlled by terraces, diversions, and other flood-control structures.

CAPABILITY UNIT IIIc-1

In this unit are moderately sloping to strongly sloping, uneroded soils of the Burchard, Morrill, and Shelby series. These are deep, well drained and moderately well drained soils on uplands. The surface layer is loam or clay loam; the subsoil is clay loam or sandy clay loam; and the underlying material is sandy loam or clay loam. In places, a few stones and boulders are on the surface.

These soils have moderately slow permeability and high available water capacity. Surface runoff is medium. Natural fertility is medium or high. Moisture is released readily. The surface layer is medium acid.

Water erosion is the principal hazard on these soils. Rainfall needs to be conserved. Other concerns of management are maintaining the content of organic matter, the soil fertility, and tilth.

All the crops commonly grown in the county, such as grain sorghum, corn, soybeans, clover, and alfalfa, are suited to these soils. Grasses, trees, and shrubs are also suited. These soils are suitable for the development of windbreaks and wildlife habitat. In places, they are suitable for the construction of farm ponds and dams.

Proper management of crop residue insures the rapid intake of water and helps maintain the content of organic matter, the soil structure, and soil tilth. A cropping system that includes a legume or a legume-grass crop every few years helps to keep the soils open for the intake of water. Terraces, grassed waterways, and contour farming help to control runoff and erosion. If mechanical conservation practices are not used, the soil can be protected by limiting use of clean-cultivated row crops and by making maximum use of close-growing crops or legume-grass crops. Row crops can be used more frequently in the cropping sequence if terraces, waterways, and contour farming are used.

CAPABILITY UNIT IIIc-2

In this unit are gently sloping, slightly or moderately eroded soils of the Benfield, Mayberry, Pawnee, and Wymore series. The Benfield soils are moderately deep and the rest are deep. The surface layer is loam, clay loam, or silty clay loam; the subsoil is silty clay or clay; and the underlying material is silty clay loam or clay loam.

These soils have slow permeability and moderate to high available water capacity. Natural fertility is high. Runoff is medium. Moisture is released slowly. These soils are easy to work. The clayey subsoil restricts movement of moisture and air. The surface layer is slightly acid or medium acid.

Water erosion is the principal hazard when cultivating these soils. Conservation of the available moisture, through slowing or preventing surface runoff, is also needed. Maintaining fertility, the content of organic matter, and soil tilth are other concerns of management.

The crops commonly grown in the county are suited to these soils. Grain sorghum and wheat are the main crops (fig. 19). Corn, alfalfa, red clover, and soybeans are also grown. Many farmers prefer grain sorghum to corn because it can better survive hot, dry periods. Some farmers prefer wheat because it first uses moisture stored in the soil and then uses moisture provided by rains early in spring. Also suited to these soils are grasses and trees for use as windbreaks and wildlife habitat. A few areas are suitable for the construction of farm ponds and erosion-control structures.

Heavy applications of fertilizers in dry years may not increase production because the heavy clay subsoil releases moisture slowly. Proper management of crop residue insures a high intake rate of water and maintains the content of organic matter, the soil structure, and soil tilth. The use of terraces, grassed waterways,



Figure 19.—Contour farming and stripcropping are the important conservation practices on this Class III land. The soil is Pawnee clay loam, 3 to 9 percent slopes.

and contour farming helps to control runoff and erosion. If mechanical practices are not used, row crops should be limited and more close-growing crops or legume-grass crops should be grown to help protect the soil from erosion. If terraces, waterways, and contour farming are used, row crops can be used safely in the cropping sequence. Because these soils sometimes have a low reserve of moisture, some farmers use a cropping system that consists mainly of such close-growing crops as wheat, red clover, alfalfa, and grasses.

CAPABILITY UNIT IIIw-1

Wabash silty clay is the only soil in this unit. It is a deep, poorly drained, nearly level soil on bottom lands. The underlying material is silty clay.

This soil has slow permeability and moderate available water capacity. Natural fertility is high. It is a fertile soil that retains moisture and plant nutrients well. It absorbs and releases moisture slowly, and is difficult to work because it stays wet for long periods of time. This soil has a firm consistency when moist. The clayey soil restricts movement of water, air, and plant roots. Runoff is very slow. The surface layer is slightly acid.

The principal limitation of this soil is wetness. The maintenance and improvement of tilth and fertility are concerns of management.

Wheat, grain sorghum, legumes, soybeans, and forage sorghum are well suited to this soil. Some farmers prefer grain sorghum or soybeans to corn because they can be planted late in spring. Other farmers prefer to plant wheat during fall. Because the deep tap roots open the clay subsoil, alfalfa is well suited to this soil. Soybeans are a good cash-grain crop, and forage sorghum is used as feed for livestock. This soil

is also suited to grasses, trees, and shrubs for use as windbreak and wildlife habitat.

Surface drainage can be improved by arranging row direction and using surface bedding and land grading. Interceptor tile systems are suitable for use in small areas having seepage problems. Excessive compaction needs to be avoided, particularly when the soil is wet, because compaction further reduces the permeability to air and water. Crop residue is beneficial for improving the content of organic matter.

CAPABILITY UNIT IIIw-2

Wabash silty clay loam is the only soil in this unit. It is a deep, poorly drained, nearly level soil on bottom lands. The underlying material is silty clay.

This soil has slow permeability and moderate available water capacity. Surface runoff is very slow. Moisture is released slowly. Natural fertility is high. Workability is fairly easy if the soil is tilled at the correct moisture content.

Wetness is the principal limitation of this soil. The soil dries slowly following rains and has slow surface runoff.

The crops commonly grown in the county, such as corn, soybeans, wheat, alfalfa, and grain sorghum, are suited to this soil. Grain sorghum and soybeans can be planted later than corn. Some legumes, such as alfalfa, have deep tap roots that open the clayey soil. Alfalfa also makes good use of moisture deep in the soil. Forage sorghum is also grown for use as livestock feed.

The use of correct row direction, surface bedding, and land grading and leveling improve drainage. Interceptor tile drains remove seepage water near the base of upland slopes. Management of crop residue, timely tillage, and applications of fertilizer help to maintain the fertility, structure, and tilth.

CAPABILITY UNIT IV-1

In this unit are the moderately steep soils of the Burchard, Morrill, and Shelby series and the moderately sloping to moderately steep soils of the Malcolm series. These are deep, well drained and moderately well drained soils on uplands. The surface layer is loam, silt loam, or clay loam. The subsoil is clay loam or silty clay loam. The underlying material ranges widely from clay loam to sandy loam.

These soils have moderate or moderately slow permeability. Available water capacity is high. Moisture is released readily. Runoff is rapid, and, for this reason, moisture is not absorbed so readily on these soils as on less steep soils. The soils are easy to work. The surface layer is medium acid.

Water erosion is a severe hazard on these soils. Steepness limits the effective use of some farm machinery on these soils and makes construction and maintenance of terraces and grassed waterways difficult. Soil tilth and fertility need to be maintained.

If properly managed, these soils are fairly well suited to the crops commonly grown in the county. They are well suited to legumes and grasses and, in places, are used for pasture. The Burchard soils are particularly well suited to legumes. These soils are also suited to trees for use in windbreaks and for use as wildlife habitat. In places, these soils are suitable for constructing farm ponds, dams, and other structures.

If these soils are cultivated, a cropping system can be used that consists mainly of such close-growing crops as small grains, legumes, and legume-grass mixtures. The objective is to use legumes and grasses about one-third of the time, and to protect the soil with a cover crop about two-thirds of the time. Use of row crops needs to be limited. A row crop-clover sequence can be repeated several times before alfalfa is planted again. Then an alfalfa-grass mixture can be used for pasture or for hay. Maintaining the content of organic matter and conserving moisture are concerns of management on these soils. Terraces, grassed waterways, and contour farming help to control runoff and erosion. If intensive management and a suitable cropping sequence cannot be used, these soils are better suited to permanent grasses.

CAPABILITY UNIT IV-4

In this unit are gently sloping, severely eroded soils of the Benfield, Mayberry, Pawnee, and Wymore series. These are moderately deep and deep soils on uplands. They have a silty clay or clay surface layer and subsoil. The underlying material ranges from silty clay loam to clay.

These soils have slow permeability and moderate to high available water capacity. Most of the original surface layer has been removed through water erosion, and the present surface layer consists of material that was originally the subsoil. The clayey texture makes tillage difficult. The subsoil, in places, resembles a claypan in that it is not easily penetrated by roots, water, or air. Runoff is rapid. The content of organic matter is low. Fertility is generally low. Moisture is absorbed and released slowly.

Water erosion is a severe hazard on these soils. Control of surface water, improvement of soil tilth, improvement of the content of organic matter, and maintenance of fertility are concerns of management. These soils are droughty during periods of low rainfall.

These soils can be used for cultivated crops but they are only fairly suitable for this use. The crops that are best suited and most often grown are wheat, clover, alfalfa, and grain sorghum. A few areas are in grass. These soils are also suitable for use as wooded areas, wildlife habitat, and sites for farm ponds.

If these soils are cultivated, a cropping system can be used that consists mainly of close-growing crops, such as small grains, legumes, and legumes-grass mixtures. Legumes and grasses can be grown about one-half of the time and a protective cover crop the rest of the time. Use of row crops in the cropping sequence needs to be limited. An example of a short crop sequence is alternated clover and wheat. A longer sequence consists of alfalfa or an alfalfa-grass mixture, grain sorghum, and clover. Terraces, sod waterways, and contour farming help to control runoff and erosion.

Heavy applications of fertilizer need to be avoided in dry years, because the clayey subsoil does not absorb or release enough moisture for plants to utilize the nutrients. Depending on the kind of farming practiced, cover crops, green-manure crops, and barnyard manure are beneficial. Returning crop residue to the soil improves the content of organic matter, soil tilth, fertility, and the intake rate of water. Applying barnyard manure is an excellent practice where small tracts of these soils are within areas of more productive soils. If intensive management and a suitable cropping sequence are not used, these soils are better suited to permanent grasses for forage and grazing.

CAPABILITY UNIT IV-8

Morrill soils, 5 to 12 percent slopes, severely eroded, are the only soils in this capability unit. These are well-drained soils on uplands. The surface layer ranges widely from sandy loam to clay loam. The subsoil is mostly clay loam. The underlying material is sandy loam.

These soils have moderately slow permeability and high available water capacity. Runoff is medium to rapid. Because of severe erosion, the content of organic matter and the fertility are low. Moisture is absorbed and released readily. These soils are fairly easy to till. They are highly responsive to good management. The surface layer is medium acid.

Water erosion is the most severe hazard if these soils are cultivated. Surface water needs to be conserved. Improving the content of organic matter and the fertility are other important concerns of management.

The soils are fairly suitable for many of the crops commonly grown in the county. They are best suited to alfalfa, wheat, clover, and grasses and are least suited to corn and sorghum. These soils also are suitable for use as wooded areas, wildlife habitat, and, in places, as sites for farm ponds.

A cropping system that consists mainly of such close-growing crops as small grains, legumes, or

legume-grass mixtures, is best suited to this soil. The objective is to grow legumes or grass one-third to one-half of the time and to protect the soils with a cover crop the rest of the time. Row crops need to be limited in the cropping system. Erosion can be controlled by such intensive management practices as terracing, contour farming, managing residues, sodding waterways, and controlling gullies.

If livestock are raised, alfalfa hay and grass pasture can be used profitably. The livestock provide manure to help maintain the fertility and the content of organic matter. Sweet clover can be used as a green-manure crop, or organic-residue crop. If intensive management and a suitable cropping system are not used, this soil is better suited to permanent grasses for forage or grazing.

CAPABILITY UNIT IV-9

Steinauer clay loam, 5 to 12 percent slopes, is the only soil in this unit. It is a deep, well-drained soil on uplands. The underlying material is clay loam.

This soil has moderately slow permeability and high available water capacity. Natural fertility is medium. Runoff is medium to rapid. This soil is somewhat easy to work. Moisture is absorbed and released readily to plants. Because it has a thin surface layer and is moderately sloping to strongly sloping, it is only fairly suited to cultivated crops. The surface layer is moderately alkaline.

Water erosion is the main hazard on this soil. Surface water needs to be conserved. Other concerns of management are increasing the content of organic matter and improving fertility. In places, stones are on the surface of this soil.

This soil is well suited to mixtures of legumes and grasses. Corn, grain sorghum, winter wheat, alfalfa, and clover are suited to the soil. Trees in windbreaks and grasses are also suited. In places these soils can be developed for use as wildlife habitat and as sites for farm ponds.

Terracing, sodded waterways, and contour farming are practices that help to control water erosion. Gullies can be filled in or shaped and seeded to grass. Using legume and grass mixtures about one-half of the time in a cropping system helps to protect the soil. Row crops need to be limited to not more than a single year in succession. Barnyard manure can be used to improve the fertility and content of organic matter. Clover is a good green-manure crop. Fertilizer is commonly needed to maintain fertility. Applications of lime are not needed on this soil, as it normally contains an excess amount. If intensive management and a suitable cropping system are not used, this soil is better suited to permanent grasses for forage and grazing.

CAPABILITY UNIT Vw-7

Only Wet alluvial land is in this unit. It consists of deep, silty to clayey soil material on bottom lands. It is nearly level and very poorly drained.

Permeability of the soil material ranges from moderate to moderately slow. Soil material is wet throughout, mainly because it receives seepage water from

adjacent uplands. The content of organic matter is high. Moisture is released readily.

Excessive wetness is a limitation of this land type. It is not practical to cultivate because of excessive wetness.

The vegetation consists mainly of coarse grasses, sedges, and rushes (fig. 20). The amount and kind of vegetation depends on the degree of wetness. A few areas are ideal for use as wildlife habitat. Others produce good forage for hay or pasture. Where the stands of grass are poor, the area can be reseeded to suitable grasses, such as reed canarygrass or tall wheatgrass. Proper management, such as restricting grazing in winter and early in spring helps to prevent the grasses from becoming woody and unpalatable. Mowing helps to control willows. A few tracts need spraying. Some sites can be fenced for used as wildlife habitat. In places, dugouts can be developed to provide water for livestock.

CAPABILITY UNIT VI-1

Malcolm complex, 12 to 25 percent slopes, is the only soil in this unit. It is a deep, well-drained soil on uplands. The surface layer is dominantly silt loam, but in places it is silty clay loam. The subsoil is silty clay loam. The underlying material is commonly stratified very fine sandy loam and silty clay loam, but its range includes coarser and finer textures.

The soil has moderate permeability and high available water capacity. Moisture is released readily. The soil retains plant nutrients well and roots penetrate it easily. Runoff is rapid. The surface layer ranges from medium acid to slightly acid.

Water erosion is the main hazard on this soil. The soil is too steep and too erodible for cultivated crops. Moisture needs to be conserved by slowing runoff.

This soil is well suited to grasses, and most areas are in grass. The soil is also suitable for planting tree in windbreaks and for developing for use as wildlife habitat. A few areas are favorable for constructing stockwater dams, farm ponds, and grade-control structures.

Good grass management that leaves a plant cover to protect the soils from erosion and, at the same time, produces a high yield of forage is desirable on this soil. If grazing is controlled so that about one-half of the grass forage is harvested each year, the grass plants can then manufacture food in their leaves and store it in their roots to maintain a healthy stand. The residue that remains on the soil reduces runoff, helps to collect and store soil moisture, and reduces the growth of woody plants and weeds. A few pastures need reseeding to adapted grasses. Under good management, the more desirable grasses become dominant. If a regulated grazing program cannot be used, the pasture can be rested until plant vigor is restored.

CAPABILITY UNIT VI-4

Pawnee and Mayberry soils, 9 to 12 percent slopes, severely eroded, are the only soils in this unit. These are deep, moderately well drained soils on uplands. The surface layer is silty clay loam, silty clay, or clay. The subsoil is clay, and the underlying material is silty clay or clay.



Figure 20.—This tract of Class V land is Wet alluvial land. Notice the abundance of coarse grass vegetation.

These soils have slow permeability and moderate available water capacity. They are not easily penetrated by roots, water, or air. These soils have poor tilth and are difficult to work. Moisture is released slowly. Runoff is rapid. The content of organic matter and the fertility are low. The surface layer is medium acid to slightly acid.

Water erosion is the main hazard on these soils. Gullies are common and form readily. The content of organic matter and the fertility need to be increased. Surface water needs to be conserved.

These soils are too steep and too erodible for cultivated crops. They are best suited to permanent grasses or trees. They can also be used as wildlife habitat. These soils are suitable for dams, farm ponds, and grade-control structures.

Areas that are cultivated or that have poor cover can be returned to permanent vegetation by seeding to grass. In order to maintain a healthy stand, pasture

and range need to be managed so that only about one-half of the vegetation is harvested each year. Gullies can be reshaped and reseeded and then protected by grade-control and erosion-control structures.

CAPABILITY UNIT VIc-8

Morrill soils, 12 to 17 percent slopes, severely eroded, are the only soils in this unit. They are deep, well-drained soils on uplands. The surface layer ranges from sandy loam to clay loam. The subsoil is clay loam and sandy clay loam, and the underlying material is sandy loam.

These soils have moderate permeability and high available water capacity. The intake rate of water is medium, and runoff is rapid. These soils retain plant nutrients, and roots can penetrate the soils easily and deeply. Because they are severely eroded, however, the soils are low in content of organic matter. The surface layer is medium acid.

Water erosion is the main hazard on these soils. Moisture needs to be conserved.

These soils are too steep and too erodible for cultivated crops. They are well suited to grasses and trees, and are well suited to use as wildlife habitat. A few areas are also suitable for farm ponds, dams, and grade-control structures.

Areas of these soils were cultivated at one time. A few of these areas have since been seeded to grass. Converting to native grasses helps to control erosion. Seeded areas need proper management to insure a good cover of grass. Proper stocking, deferred grazing, and control of weeds and brush help to establish and maintain a good stand of grass. Controlled grazing that leaves one-half of the vegetation for the following year allows the grasses to store food in their root systems.

CAPABILITY UNIT VI-9

Steinauer clay loam, 12 to 21 percent slopes, is the only soil in this unit. It is a deep, well-drained soil on uplands. The surface layer and underlying material are clay loam. Lime is at or near the surface.

This soil has moderately slow permeability and high available water capacity. Natural fertility is medium. This soil retains plant nutrients well, and roots can penetrate it easily and deeply. The content of organic matter is low. Moisture is released readily.

This soil is well suited to grasses, and nearly all the acreage is used as hayland or rangeland. It is also suited to trees and shrubs in windbreaks and to use as wildlife habitat. Many areas are favorable sites for dams, farm ponds, and erosion-control structures.

This soil is subject to severe erosion if the vegetation is removed. The principal concern of management

is maintaining a good cover of grass. The moderately steep and steep slopes make this soil unsuitable for cultivation. Grazing that leaves one-half of the vegetation for the following year enables the grass to store nutrients in the root system and insures a healthy stand of range grasses. Proper stocking, deferred grazing, and rotation grazing are needed to maintain the proper kinds and amounts of grass.

CAPABILITY UNIT VI-4

Only Kipson-Benfield silty clay loams, 5 to 17 percent slopes, is in this unit (fig. 21). This complex consists of shallow and moderately deep soils that are well drained and somewhat excessively drained. The surface layer is silty clay loam. The subsoil of the Benfield soil is silty clay. Underlying material is silty clay loam. Depth to silty and clayey shale bedrock ranges from 10 to 40 inches.

Permeability ranges from moderately slow to slow. Available water capacity is low or moderate. Natural fertility is low or high. The intake rate of water is moderately slow. Runoff is rapid. Moisture is released readily. The surface layer is slightly acid to mildly alkaline.

The shallow Kipson soil makes up one-half of the acreage of this unit, and its low available water capacity is a limitation to the use of this soil. Outcrops of bedrock, steepness and uneven slopes, and sudden changes in the soil are also limitations. Drought is a hazard during periods of little rainfall. Moisture needs to be conserved. These soils are subject to erosion if vegetation is removed. They are suited to grass and trees. Wildlife use these areas as habitat and as a source of food. A few areas are suitable for the construction of dams and farm ponds.



Figure 21.—Landscape of capability unit VI-4. The soils are Kipson-Benfield silty clay loams, 5 to 17 percent slopes.

Properly managed areas of these soils are suitable for production of forage. The shallower soils produce less forage than the deeper ones. Areas with poor grass cover can be reseeded to grass. Deferred grazing, rotation grazing, and proper stocking are needed. Grazing that leaves one half the vegetation on the soil keeps the plants vigorous and healthy. Good grass management helps to reduce runoff and to store moisture for use during dry periods.

CAPABILITY UNIT VI_w-7

Only Silty alluvial land is in this unit. It consists of deep, nearly level soil material on narrow bottom lands. The areas are dissected by meandering streams and are frequently flooded. The soil material is stratified silt loam, but in places there are layers of coarser or finer textured sediment.

In most places, this material has moderately slow permeability and high available water capacity. Runoff is slow. The soil material is highly fertile. Fresh alluvium is added each time the soil is flooded. Moisture is absorbed and released readily.

Flooding is the principal hazard on these soils. The small areas formed by the meandering channel are difficult to cultivate. Very heavy rains scour these areas and deposit debris in places.

Areas of this land type are best suited to grass or trees. A few areas are suitable sites for dugouts to use as a source of water for livestock. Many areas provide good habitat for wildlife.

Maintaining a stand of the most desirable grasses is a concern of management. Once established, the better grasses maintain themselves if they are protected from overgrazing. Rotation grazing, deferred grazing, and proper stocking are range practices needed to maintain a healthy stand of grass.

Wooded areas can be protected by restricting grazing, by removing less desirable and poorly formed trees, by supplemental planting, and by pruning. Properly managed stands of black walnut trees can be a good source of income.

CAPABILITY UNIT VII_e-7

Only Rough broken and gullied land is in this unit. It consists of excessively drained, very steep soil material in narrow bands along upland drainageways. The soil material is deep and ranges widely from silt loam to clay. It is made up of loess, glacial till, and alluvial material.

Permeability ranges from moderate to slow, depending on the kind of material. Available water capacity is high or moderate. Runoff is very rapid.

The gullied part of this land type is nearly barren. The rough broken part is commonly covered by mixed grass, shrubs, and trees. These areas are fair to good for grazing livestock and for woodland. They are excellent habitat for many species of wildlife.

Management that increases the vegetative stands helps to control gullies. Tracts can be fenced to keep out livestock. These areas are then ideal for use as wildlife habitat. A few areas are suitable for dams and ponds, but care is needed in selecting the site for proper foundation and fill material. Because of the

very steep slope and the gullied channels, extreme care is needed if the areas are used for grazing livestock. Grade-control structures can be used to stabilize active gullies. Areas that are fenced can be used for production of walnut lumber if trees are planted in the floors of channels and are protected from burning. Less desirable species need to be removed.

CAPABILITY UNIT VII_e-4

Only Kipson-Sogn complex is in this unit. These are shallow, moderately steep to very steep soils on uplands. They are underlain by shale or limestone bedrock at a depth of 5 to 20 inches. In places, bedrock crops out at the surface on the steepest areas and on ledges.

Permeability of the soils is moderately slow. Available water capacity is low or very low. Runoff is very rapid. Moisture intake is moderate, and moisture is released readily to plants. Natural fertility is low.

The low and very low available water capacity makes these soils droughty during periods of little rainfall. It is difficult for plants to become established in the limited amount of soil material that is available. The slopes and stoniness severely restrict the use of most kinds of machinery.

Areas of this complex are suited to grazing, hayland, and habitat for wildlife. The plant community consists of native and tame grasses, small areas of shrubs, osageorange, and locust. In places there are hardwood trees on deeper soils next to drainageways. There are some suitable sites for farm ponds, but seepage is a serious concern and the sites need to be carefully investigated. Some areas provide fine scenic views.

The principal concern of management of the grassland is to maintain adequate grass cover. Grazing needs to be controlled so as to help firmly establish and maintain the plants. Leaving about one-half or more of the vegetation each year at the end of the growing season helps to maintain a healthy stand of grass.

In places, woody shrubs can be removed to allow grasses to become the dominant vegetation. The main need for the development of wildlife habitat is to provide food and maintain proper plant cover for protection of wildlife. This need can be met by not letting livestock graze the area to be used as wildlife habitat.

Management of tame pasture²

Tame-grass pastures in Pawnee County are made up mostly of cool-season grasses. The grasses begin growing early in spring and grow most during May and June. The grasses often become dormant during the warm summer months of July and August, but grow well during the cooler fall months. For this reason, it is desirable to have a planned season-long grazing system that provides green pasture for livestock throughout the growing period. A combination of cool-season pastures, warm-season pastures or range, and an annual planting of sudangrass provides this season-long grazing.

² By ERVIN O. PETERSON, conservation agronomist, Soil Conservation Service.

Well-managed pastures are grazed when the forage is at its peak in quality and quantity. In Pawnee County, this is during the months of May, June, and September. Maintaining a stand of grass is also a concern of management. Cool-season pastures yield more forage than native warm-season grasses, but they are more costly to maintain. Because of their high productivity and good response to fertilizer, such soils as Kennebec, Colo, Judson, Wymore, and Crete are best used as pasture.

Bromegrass, an introduced cool-season grass, is the most commonly used grass in Pawnee County. Such grasses as orchardgrass, reed canarygrass, and tall fescue and such legumes as alfalfa and birdsfoot trefoil can be added to the bromegrass to create a pasture that has wider potential and more consistent production than a pasture consisting of a single species.

When pastures become low producers, it is desirable to plow the old stand and to reestablish the desired grasses. For this reason, it is important the cool-season grasses be planted on soils that can be plowed and reseeded without danger of excessive runoff and erosion.

Plants grow to a height of five or six inches using food reserves stored in their roots and rhizomes. Grazing plants too early in spring removes this growth and causes a serious weakening of the plant that results in low production during the rest of the year. Controlling grazing to insure that plants never have less than four inches of leaf growth and to insure that they have a six- to eight-inch growth at about the time of the killing frost in fall provides for storage of food for growth the following spring.

Production of pastures can be increased by applications of fertilizer. Cool-season grasses respond well to nitrogen applied early in spring. If a legume is included in the pasture mixture, phosphate fertilizer is needed for high production. The amount of available soil moisture and the results of soil tests should be used as guides to determine the kind and amount of fertilizer needed.

Sudangrass can be used to supplement a cool-season pasture during warm summer months. Its production is highest during July and August, the time when cool-season grasses are semidormant. Season-long grass production can be attained by a combination of cool-season pastures and temporary sudangrass pastures. An even more stable forage-production program can be obtained by using native warm-season grasses in this combination.

Predicted yields

Table 2 lists the predicted yields per acre for the principal crops grown on soils of Pawnee County. These predictions are based on information furnished by farmers, supervisors of soil and water conservation districts, representatives of the Soil Conservation Service and the Agricultural Extension Service, and personnel of the Agriculture Stabilization and Conservation Service and the Agricultural Experiment Stations.

Crop yields are influenced by many factors. Among the most influential soil features are depth, texture,

slope, and drainage. Also important are erosion, available water capacity, permeability, and fertility. Important concerns of management include the selection of the most suitable cropping pattern, type of tillage operation, plant population, and crop variety. Weather is also significant, both on a day-to-day basis and on a seasonal or yearly basis. During favorable years, the yields of dryfarmed crops are higher than those listed in the table. If the crops are damaged by hail or other unpredictable natural phenomena, yields are lower than those listed.

The yields in table 2 are listed under two levels of management. Those in columns A can be expected under average management. Under average management moderate amounts of fertilizer are applied; organic matter is not always returned to the soil; the soil is not always kept in good tilth; more erosion-control practices are needed; certified seed is not always used; and weeds, insects, and diseases are not adequately controlled.

Yields in columns B can be expected under a high level of management. Under a high level of management fertilizer of a kind and in an amount indicated by soils tests and field experience is applied; crop residue is returned to the soil to maintain the content of organic matter and to improve tilth; practices that control erosion are used; certified seed is used; the plant population is adequate; weeds, insects, and diseases are controlled; and approved methods of tilling are used.

Use of the Soils for Range³

About 32 percent of the total farmed acreage in Pawnee County is range and pasture. The soils used as range generally are not suitable for cultivation. The largest areas of rangeland are in the Benfield-Kipson-Sogn and the Pawnee-Mayberry-Burchard associations.

Raising of livestock, mainly cow-calf herds, is the largest agricultural industry in the county. The calves are sold in fall as feeders.

Management and improvement of range

The use of proper grazing, deferred grazing, and planned grazing systems maintains or improves the condition of range. These practices are needed on all rangeland. The distribution of livestock in a pasture can be improved by correct locating of fences, livestock water, and salt.

Seeding wild or improved strains of native grasses improves the condition of range. Soils, such as Steinauer clay loam, 12 to 21 percent slopes, that are still being used as cropland are better suited to use as range. Among the grasses suitable for seeding are big bluestem, little bluestem, switchgrass, indiagrass, and side-oats grama. After seeding, little care other than management of grazing is needed to maintain forage production.

³ By PETER N. JENSEN, range conservationist, Soil Conservation Service.

TABLE 2.—*Predicted yields per acre of principal crops*

[Yields in columns A are those to be expected under ordinary management; yields in columns B are those to be expected under improved management. Absence of yield indicates the crop is not suited to the soil or that it is grown only in small amounts]

Soil	Corn		Grain Sorghum		Wheat		Alfalfa	
	A	B	A	B	A	B	A	B
	<i>Bu</i>	<i>Bu</i>	<i>Bu</i>	<i>Bu</i>	<i>Bu</i>	<i>Bu</i>	<i>Tons</i>	<i>Tons</i>
Benfield silty clay loam, 3 to 9 percent slopes, eroded.....	34	56	45	75	23	35	2.0	3.5
Benfield soils, 3 to 9 percent slopes, severely eroded.....	20	44	30	60	18	28	1.0	3.0
Burchard clay loam, 5 to 12 percent slopes.....	39	56	46	73	20	30	3.0	4.5
Burchard clay loam, 12 to 17 percent slopes.....	24	42	33	50	18	23	2.5	4.0
Butler silt loam.....	35	55	50	65	25	35	2.0	3.5
Colo and Kennebec soils, occasionally flooded.....	55	95	55	90	18	23	3.5	5.0
Crete silt loam, terrace.....	46	72	52	82	26	35	3.0	4.5
Judson silt loam, 1 to 5 percent slopes.....	65	100	63	105	30	40	3.5	4.5
Kennebec silt loam.....	80	110	75	110	25	38	4.0	5.0
Kipson-Benfield silty clay loams, 5 to 17 percent slopes.....								
Kipson-Sogn complex.....								
Malcolm complex, 5 to 12 percent slopes.....	40	58	47	74	24	30	2.5	4.0
Malcolm complex, 12 to 25 percent slopes.....								
Mayberry loam, 3 to 9 percent slopes.....	33	55	44	75	25	35	3.0	3.5
Mayberry clay loam, 3 to 9 percent slopes, eroded.....	30	50	42	68	22	32	2.0	3.0
Mayberry soils, 3 to 9 percent slopes, severely eroded.....	20	40	28	57	18	25	1.0	2.5
Morrill loam, 3 to 5 percent slopes.....	45	68	55	80	24	30	2.5	4.0
Morrill loam, 5 to 12 percent slopes.....	40	65	45	70	22	28	2.0	3.5
Morrill loam, 12 to 17 percent slopes.....	30	42	35	54	20	24	1.5	3.0
Morrill soils, 5 to 12 percent slopes, severely eroded.....	30	60	38	60	20	26	1.5	3.0
Morrill soils, 12 to 17 percent slopes, severely eroded.....								
Pawnee loam, 0 to 3 percent slopes.....	43	65	60	78	28	35	3.0	4.0
Pawnee loam, 3 to 9 percent slopes.....	40	60	46	78	23	33	2.5	3.5
Pawnee clay loam, 3 to 9 percent slopes, eroded.....	35	60	50	68	20	32	2.0	3.0
Pawnee soils, 3 to 9 percent slopes, severely eroded.....	25	42	35	58	18	27	1.5	2.5
Pawnee and Mayberry soils, 9 to 12 percent slopes, severely eroded.....								
Rough broken and gullied land.....								
Shelby clay loam, 5 to 12 percent slopes.....	41	58	49	75	23	33	3.5	4.5
Shelby and Burchard clay loams, 12 to 17 percent slopes.....	26	45	35	55	20	28	3.0	4.0
Silty alluvial land.....								
Steinauer clay loam, 5 to 12 percent slopes.....	24	40	33	60	18	28	2.5	4.5
Steinauer clay loam, 12 to 21 percent slopes.....								
Wabash silty clay loam.....	50	75	56	82	24	32	3.5	4.5
Wabash silty clay.....	40	65	40	65	18	26	3.0	4.0
Wet alluvial land.....								
Wymore silty clay loam, 0 to 3 percent slopes.....	50	70	52	90	25	35	3.0	4.5
Wymore silty clay loam, 3 to 7 percent slopes.....	45	68	50	80	25	35	2.5	4.0
Wymore silty clay loam, 3 to 7 percent slopes, eroded.....	35	65	47	78	23	33	2.5	4.0
Wymore soils, 3 to 7 percent slopes, severely eroded.....	30	48	37	65	20	30	1.5	3.0

Range sites and condition classes

Different kinds of range produce different kinds and amounts of native grass. For proper range management, an operator needs to know the different kinds of soil or range sites in his holding and the native plants each site can grow. Management that favors the growth of the best forage plants on each kind of soil can then be used.

Range sites differ from each other in their ability to produce a significantly different kind or amount of climax or original vegetation. A significant difference is one great enough to require some variation in management, such as a different stocking rate. Climax vegetation is the combination of plants that originally grew on a given site. The most productive combination of range plants on a site is generally the climax vegetation.

Range condition is classified according to the percentage of original, or climax, vegetation on the site.

This classification is used in comparing the kind and amount of present vegetation with that which the site can produce. Changes in range condition are caused mainly by the intensity of grazing and by drought.

Vegetation is altered by intensive grazing. Livestock graze selectively. They seek the more palatable and nutritious plants. Plants react to grazing in one of three ways. They decrease, increase, or invade. Decreaser and increaser plants are both part of the climax vegetation. Generally, *decreasers* are the most heavily grazed and, consequently, the first to be injured by overgrazing. *Increasers* withstand grazing better because they are less palatable to livestock. They increase under grazing and replace the *decreasers*. *Invaders* are weeds that become established after the climax vegetation has been reduced by grazing.

Range condition indicates the degree to which the composition of the existing plant community differs from the climax vegetation. Four classes are recog-

nized. The condition is *excellent* if 76 to 100 percent of the vegetation is climax; *good* if 51 to 75 percent is climax; *fair* if 26 to 50 percent is climax; and *poor* if 0 to 25 percent is climax.

Descriptions of range sites

The nine range sites in Pawnee County are described in this section (figs. 22 and 23). The descriptions include the topography in each site, a brief description of the mapping units in each site, the dominant vegetation on a site in excellent condition, the dominant vegetation on a site in poor condition, and the total annual yield in pounds per acre, air-dry weight, when the site is in excellent condition.

The names of the soil series and land types in a range site are given in the description of the range site, but this does not mean that all the soils of a given series are in that site. To find the names of all the soils in any given site, refer to the "Guide to Mapping Units" at the back of this survey. The range site for each mapping unit is given in the "Guide to Mapping Units."

WET LAND RANGE SITE

Wet alluvial land is the only mapping unit in this site. This land type is on bottom lands. It consists of

deep, dark silt loam to silty clay loam. In areas where this land type is nearly level, the lower part is silty clay. Seepage water that drains from adjacent uplands keeps areas of this land type wet. Permeability ranges from moderate to slow.

The kind of vegetation is determined mainly by the amount of moisture present during the growing season. At least 75 percent of the climax plant cover is a mixture of such decreaser grasses as prairie cordgrass and reed canarygrass. Perennial grasses and forbs make up the rest. Members of the sedge family are the principal increasers. The typical plant community, when in poor range condition, consists mainly of Kentucky bluegrass and sedges.

If the site is in excellent range condition, the total annual production ranges from 6,000 pounds per acre, air-dry weight, in unfavorable years to 7,000 pounds per acre in favorable years.

SILTY OVERFLOW RANGE SITE

This site consists of soils of the Colo series and of Silty alluvial land. These areas are on bottom lands that are subject to occasional flooding. The surface layer and underlying material are mainly silt loam and silty clay loam. In places, they are very fine sandy

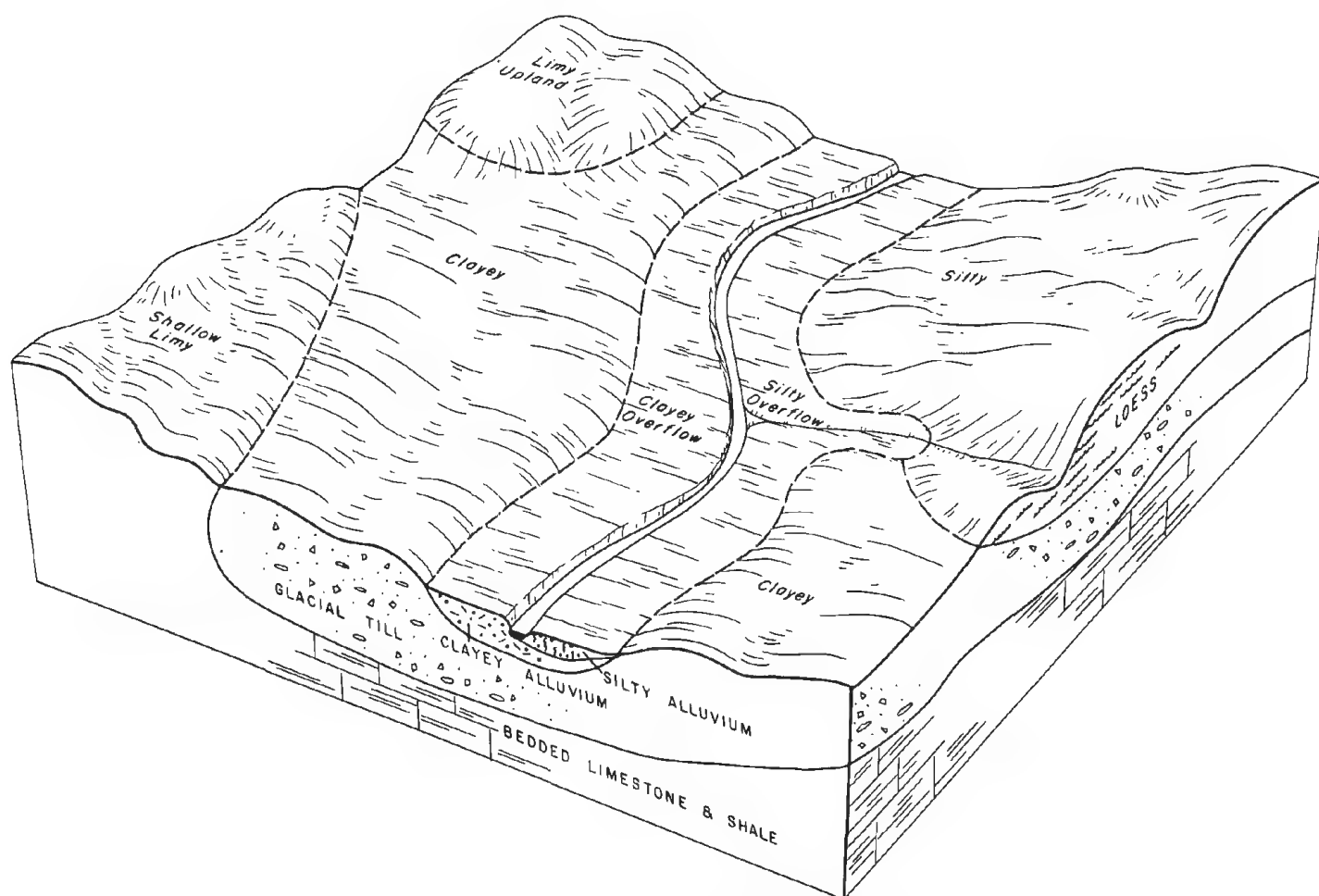


Figure 22.—Distribution of selected range sites in typical landscape in Pawnee County.

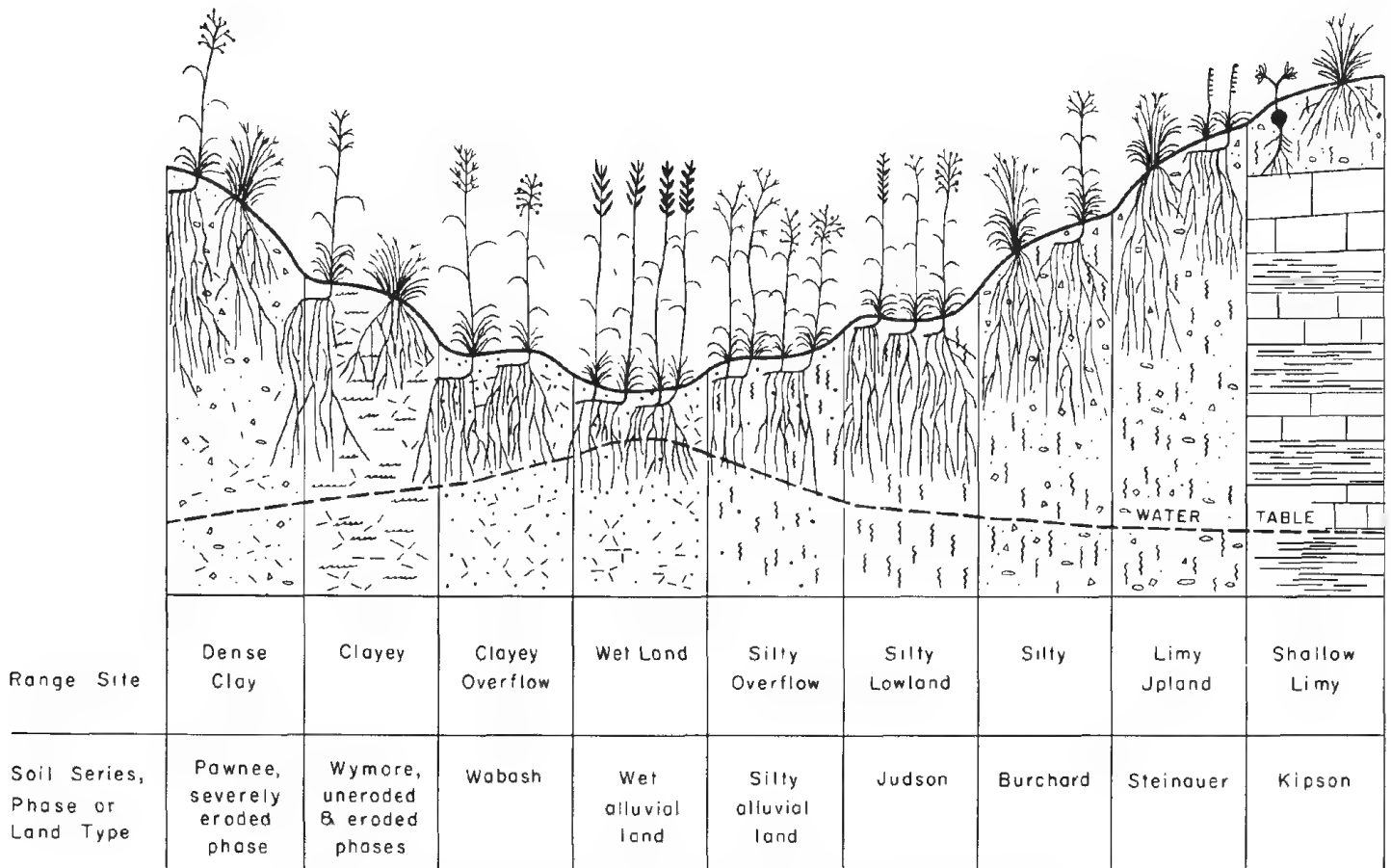


Figure 23.—Pawnee County range sites and representative soils on each site.

loam and silty clay sediment. Permeability ranges from moderate to moderately slow.

The kind of vegetation is determined mainly by the amount of water received from stream overflow. At least 75 percent of the climax plant cover is a mixture of such decreaser grasses as big bluestem, indiangrass, prairie cordgrass, and switchgrass. Perennial grasses and forbs make up the rest. Members of the sedge family are the principal increasers. The typical plant community, when in poor range condition, consists of Kentucky bluegrass, Baldwin ironweed, willows, and annuals.

If the site is in excellent range condition, the total annual production ranges from a low of 4,500 pounds per acre, air-dry weight, in unfavorable years to 6,000 pounds per acre in favorable years.

CLAYEY OVERFLOW RANGE SITE

In this site are soils of the Wabash series. These are deep, poorly drained, nearly level soils on bottom lands. The surface layer is silty clay loam or silty clay, and the underlying material is silty clay. Permeability is slow.

The kind of vegetation is determined mainly by the periodic flooding and by the slow permeability. At least 75 percent of the climax plant cover is a mixture of such decreaser grasses as big bluestem, Canada wildrye, prairie cordgrass, and switchgrass. Other pe-

rennial grasses and forbs make up the rest. Members of the sedge family are the principal increasers. The typical plant community, when in poor range condition, consists of Kentucky bluegrass, western ragweed, Baldwin ironweed, willows, and annuals.

If the site is in excellent range condition, the total annual production ranges from 3,000 pounds per acre, air-dry weight, in unfavorable years to 5,000 pounds per acre in favorable years.

SILTY LOWLAND RANGE SITE

In this site are soils of the Kennebec and Judson series. These are deep, moderately well drained and well drained soils on bottom lands and foot slopes. The surface layer is silt loam or silty clay loam. The subsoil is silty clay loam, and the underlying material is silt loam, loam, or silty clay loam. Permeability is moderate or moderately slow. A water table is at a depth of 8 to 20 feet.

The kind of vegetation is determined mainly by the amount of additional moisture received from adjacent higher elevations and by the high available water capacity of these soils. At least 70 percent of the climax plant cover is a mixture of such decreaser grasses as big bluestem, Canada wildrye, indiangrass, and switchgrass. Perennial grasses and forbs make up the rest. Little bluestem and members of the sedge family are the principal increasers. The typical plant commu-

nity, when in poor range condition, consists of Kentucky bluegrass, western ragweed, Baldwin ironweed, and annuals.

If the site is in excellent range condition, the total annual production ranges from a low of 4,000 pounds per acre, air-dry weight, in unfavorable years, to 6,000 pounds per acre in favorable years.

SILTY RANGE SITE

In this site are soils of the Burchard, Malcolm, Morrill, and Shelby series and Rough broken and gullied land. These gently sloping to very steep soils are on uplands. The surface layer is silt loam, loam, or clay loam. The subsoil is clay loam or silty clay loam. The underlying material is clay loam, silty clay loam, very fine sandy loam, or sandy loam. Permeability ranges from moderate to moderately slow.

The kind of vegetation that grows on this site is determined mainly by the high available water capacity of these deep, well drained and moderately well drained soils. At least 70 percent of the climax plant cover is a mixture of such decreaser grasses as big bluestem, Canada wildrye, indiangrass, prairie dropseed, and switchgrass. Perennial grasses and forbs make up the rest. Little bluestem and side-oats grama are the principal increasers. The typical plant community, when in poor range condition, consists of Kentucky bluegrass, western ragweed, blue verbena, Baldwin ironweed, members of the sedge family, annuals, and such woody plants as buckbrush.

If the site is in excellent range condition, the total annual production ranges from a low of 3,500 pounds per acre, air-dry weight, in unfavorable years to 5,000 pounds per acre in favorable years.

CLAYEY RANGE SITE

In this site are soils of Butler and Crete series and those soils of the Benfield, Mayberry, Pawnee, and Wymore series that are slightly or moderately eroded. These are mostly deep, somewhat poorly drained to well-drained, nearly level to moderately steep soils on uplands. The Benfield soils are moderately deep. The surface layer is silt loam, clay loam, or silty clay loam. The subsoil is silty clay or clay. The underlying material ranges from silty clay loam to silty clay.

The kind of vegetation on this site is determined mainly by the clayey, slowly permeable subsoil. At least 65 percent of the climax plant cover is a mixture of such decreaser plants as big bluestem, indiangrass, prairie dropseed, and switchgrass. Perennial grasses and forbs make up the rest. Little bluestem, side-oats grama, and tall dropseed are the principal increasers. The typical plant community, when in poor range condition, consists of Kentucky bluegrass, blue verbena, western ragweed, cool- and warm-season grasses, members of the sedge family, and such woody plants as buckbrush.

If the site is in excellent range condition, the total annual production ranges from a low of 2,500 pounds per acre, air-dry weight, in unfavorable years to 5,000 pounds per acre in favorable years.

LIMY UPLAND RANGE SITE

In this site are soils of the Steinauer series. These are deep, well-drained, moderately sloping to steep

soils on uplands. The surface layer and underlying material are clay loam. Permeability is moderately slow.

The kind of vegetation on this site is determined mainly by the calcareous, well-drained soils. At least 65 percent of the climax plant cover is a mixture of such decreaser grasses as little bluestem, big bluestem, and switchgrass. Perennial grasses and forbs make up the rest. Side-oats grama is the principal increaser. The typical plant community, when in poor range condition, consists of side-oats grama, cool- and warm-season annual grasses, and Kentucky bluegrass.

If the site is in excellent range condition, the total annual production ranges from a low of 3,000 pounds per acre, air-dry weight, in unfavorable years to 4,500 pounds per acre in favorable years.

SHALLOW LIMY RANGE SITE

In this site are soils of the Kipson and Sogn series. These are shallow, somewhat excessively drained, gently sloping to steep soils on uplands. The surface layer and transitional layer are silty clay loam. These soils are 5 to 20 inches deep over shale or limestone bedrock. Permeability above the bedrock is moderately slow.

The kind of vegetation on this site is determined mainly by the low or very low available water capacity of these shallow, calcareous soils. At least 70 percent of the climax plant cover is a mixture of such decreaser grasses as little bluestem, big bluestem, prairie dropseed, and switchgrass. Perennial grasses and forbs make up the rest. Side-oats grama and tall dropseed are the principal increasers. The typical plant community, when in poor range condition, consists mainly of side-oats grama, Kentucky bluegrass, cool- and warm-season annual grasses, and such woody plants as osageorange and honeylocust.

If the site is in excellent range condition, the total annual production ranges from a low of 2,000 pounds per acre, air-dry weight, in unfavorable years to 4,000 pounds per acre in favorable years.

DENSE CLAY RANGE SITE

In this site are the severely eroded soils of the Benfield, Mayberry, Pawnee, and Wymore series. These are mostly deep, well drained or moderately well drained, gently sloping to strongly sloping soils. The surface layer ranges from silty clay loam to clay. The subsoil is silty clay or clay. The underlying material ranges from silty clay loam to silty clay. These soils are slowly permeable.

The kind of vegetation on this site is determined mainly by the slow permeability of the clayey subsoils. At least 75 percent of the climax plant cover is a mixture of such decreaser grasses as switchgrass, big bluestem, little bluestem, indiangrass, and side-oats grama. Other perennial grasses and forbs make up the rest. Tall dropseed is the principal increaser. The typical plant community, when in poor range condition, consists mainly of Scribner panicum, tall dropseed, cool- and warm-season annual grasses, and members of the sedge family.

If the site is in excellent range condition, the total annual production ranges from a low of 2,000 pounds

per acre, air-dry weight, in unfavorable years to 4,000 pounds per acre in favorable years.

Use of Soils for Woodland and Windbreaks ⁴

Native woodland in Pawnee County is limited to somewhat narrow strips on bottom lands along drainageways and on the lower parts of steep, stony uplands. Some of this acreage is capable of producing commercial quantities of wood; however, its value for use as scenery, recreation areas, wildlife habitat, and watershed protection is even greater.

Eastern cottonwood, American elm, hackberry, green ash, willow, and other trees that can tolerate wetness grow on the bottom lands. On the steep upland slopes, the native species are bur oak, eastern redcedar, hackberry, hickory, honeylocust, green ash, American elm, and black walnut.

Early settlers in Pawnee County planted trees for protection, shade, and fenceposts; and throughout the years, landowners have continued to plant trees to protect their buildings, livestock, and soil. Native trees and shrubs contribute a great deal to the natural beauty of the Pawnee County landscape. They benefit wildlife by producing food and cover.

Windbreaks are needed for protection of farmsteads, livestock, and soils. If properly designed and located, windbreaks can control drifting snow, provide shelter for the home and livestock, and improve conditions for wildlife. They can also help to beautify the countryside.

Although trees are not easy to establish in Pawnee County, observing basic rules of tree culture can result in a high degree of tree survival. Healthy seedlings properly planted on a prepared site and maintained in good condition can survive and grow well.

Table 3 gives the expected height, at 20 years of age, of trees suited to windbreaks in Pawnee County. Detailed tree measurements were made on soils of the major windbreak suitability groups in the county. The soils in each group have similar characteristics that affect tree growth.

⁴ By JAMES W. CARR, JR., forester, Soil Conservation Service.

The ratings for vigor in table 3 are based on observations of general condition of the trees. A rating of *good* indicates that the leaves or needles are normal in color and growth; that only a few dead tops, branches, and twigs are in the live crown; and that disease, insect, and climatic damage is limited. A rating of *fair* indicates that the leaves or needles are obviously abnormal in color and growth; that substantial amounts of dead wood are in the live crown; or that moderate disease, insect, and climatic damage is obvious; and the current year's growth is obviously less than normal. A rating of *poor* indicates that the leaves or needles are very abnormal in color and growth; that a great number of dead tops, branches, and twigs are in the live crown; that disease, insect, and climatic damage is extensive; or that the current year's growth is negligible.

Eastern redcedar and pines are best suited to use in windbreaks. Measurements show that these conifers are the most reliable species for windbreaks. Both rated high in survival and vigor in the studies made. They retain their leaves throughout winter and thereby give maximum protection when it is most needed.

Such broadleaf trees as green ash, honeylocust, and hackberry are also well suited to use in windbreaks. Suitable shrubs are cotoneaster, lilac, and honeysuckle. Eastern redcedar reaches a mature height of approximately 30 to 40 feet. Pines and broadleaf trees generally grow faster than redcedar and are often somewhat taller at maturity.

The rate of growth of a windbreak varies widely with soil moisture conditions. Soil fertility, exposure of the soil, and arrangement of trees within the windbreak also have a marked effect on growth. Some species, such as eastern cottonwood, Siberian elm, and Russian-olive, grow faster than others, and some grow fast when young but die early. Boxelder and Russian mulberry commonly freeze back during severe winters. Green ash are susceptible to damage by borers.

A good windbreak is designed to fit the soil in which it is to grow. The intended purpose of the planting also needs to be considered. Specific informa-

TABLE 3.—*Relative vigor and estimated height of specified trees at 20 years of age, by windbreak suitability group*

[Windbreak suitability group 10 is not included because windbreaks are not commonly used on the soils and land types of this group]

Species	Group 1		Group 2		Group 4		Group 5		Group 9	
	Relative vigor	Average height	Relative vigor	Average height	Relative vigor	Average height	Relative vigor	Average height	Relative vigor	Average height
		<i>Feet</i>		<i>Feet</i>		<i>Feet</i>		<i>Feet</i>		<i>Feet</i>
Eastern redcedar	Good	24	Good	23	Good	21	Good	19	Good	16
Ponderosa pine	Good	30	Poor	(¹)	Good	24	Good	22	Poor	(²)
Green ash	Good	29	Fair	28	Good	26	Fair	20	(¹)	(²)
Hackberry	(²)	(²)	Fair	26	Good	23	Fair	18	(¹)	(²)
Honeylocust	Good	36	Fair	34	Fair	25	Fair	22	(¹)	(²)
Eastern Cottonwood	(²)	(¹)	Fair	54	Poor	(¹)	Poor	(¹)	(¹)	(²)
Russian-olive	(²)	(²)	Poor	(¹)	Fair	17	Fair	15	Fair	12

¹ Most trees dead or dying.

² Not sufficient data available.

tion on design, establishment, and care of windbreaks is available from the Soil Conservation Service and the Extension Service forester serving the county.

Windbreak suitability groups

The soils of Pawnee County are grouped according to the characteristics that affect tree growth. Soils in each group support similar growth and survival of trees under normal conditions of weather and care. The windbreak suitability groups in Pawnee County are not numbered consecutively because they are part of a statewide system, and not all of the groups recognized in Nebraska are in Pawnee County. The following is a brief description of the windbreak suitability groups in Pawnee County, including a list of trees and shrubs that are suitable for windbreak plantings in each group.

WINDBREAK SUITABILITY GROUP 1

In this group are deep, nearly level, moderately well drained soils on bottom lands. The surface layer and underlying material range from silt loam to silty clay loam. Permeability is moderate.

These soils are generally good sites for planting trees. Adapted species survive and grow well. Moisture competition from weeds and grasses is the principal hazard.

Species suitable for planting are such conifers as eastern redcedar, ponderosa pine, Austrian pine, Scotch pine, white pine, fir, blue spruce, and Norway spruce; such low broadleaf trees as green ash, hackberry, honeylocust, bur oak, red oak, black walnut, and sycamore; and such shrubs as honeysuckle, cotoneaster, lilac, skunkbush sumac, autumn-olive, and Amur maple.

WINDBREAK SUITABILITY GROUP 2

In this group are deep, nearly level, somewhat poorly drained and poorly drained soils. These soils are on bottom lands of creeks and rivers, along wide upland drainageways, and on loessial uplands. The surface layer ranges from silt loam to silty clay. The subsoil and underlying material range from silty clay loam to silty clay. The water table is at a depth of 3 to 15 feet in the valleys, but is considerably deeper on the uplands. In places these soils are occasionally flooded. Permeability ranges from moderately slow to slow.

Species that can tolerate occasional wetness survive and grow well on these soils. Establishment of seedlings is sometimes difficult during wet years. Controlling the abundant and persistent herbaceous vegetation on these sites during establishment of trees is a concern of management.

Species suitable for planting are such conifers as eastern redcedar, Austrian pine, Scotch pine, and Black Hills spruce; such low broadleaf trees as Russian-olive and diamond willow; such medium to tall broadleaf trees as green ash, honeylocust, white willow, golden willow, eastern cottonwood, and sycamore; and such shrubs as red-osier dogwood, silver buffaloberry, eastern chokecherry, and purple willow.

WINDBREAK SUITABILITY GROUP 4

In this group are deep, well drained to moderately well drained soils on uplands and foot slopes. The surface layer ranges from loam to silty clay loam, and is gravelly in places. The subsoil ranges from clay loam to silty clay. The underlying material is loam, silt loam, clay loam, or sandy loam. These soils range from very gently sloping to steep. Permeability is moderate or moderately slow. Soils in this group range from uneroded to severely eroded.

Adapted species survive well and grow fairly well on these soils. Drought and moisture competition from weeds and grasses are the principal hazards. Water erosion is a hazard on the gently sloping to steep soils. Because of rapid runoff, lack of sufficient moisture reduces growth of trees on the steeper slopes.

Species suitable for planting are such conifers as eastern redcedar, ponderosa pine, Austrian pine, and Scotch pine; such low broadleaf trees as Russian mulberry and Russian-olive; such tall broadleaf trees as green ash, hackberry, and honeylocust; and such shrubs as cotoneaster, lilac, skunkbush sumac, and autumn-olive.

WINDBREAK SUITABILITY GROUP 5

In this group are deep and moderately deep, well-drained, gently sloping to steep soils on uplands. The surface layer is silty clay loam, clay loam, or silty clay. The subsoil is silty clay loam or silty clay. The underlying material is clay loam or interbedded silty and clayey shale. Permeability is slow or moderately slow. Soils in this group range from uneroded to severely eroded.

Trees planted on these soils have a fair chance of survival but grow poorly. Lack of adequate moisture and moisture competition from weeds and grasses are the principal hazards. Erosion is a hazard if cultivation is used as a means of controlling weeds. Species that can tolerate a high content of lime in soils are most suitable for the areas of weakly developed soils. Species suitable for planting are such conifers as eastern redcedar, ponderosa pine, Austrian pine, and Scotch pine and such medium to tall broadleaf trees as bur oak.

WINDBREAK SUITABILITY GROUP 9

In this group are deep, moderately well drained, nearly level to strongly sloping soils on uplands. The surface layer ranges from loam to clay. The subsoil is clay. The underlying material ranges from clay loam to clay. Permeability is slow. Soils in this group range from uneroded to severely eroded.

Adapted species have a fair chance for survival and growth on these soils. Drought and moisture competition from weeds and grasses are the principal hazards. Water erosion is a hazard on the gently sloping to strongly sloping soils. The soils of this group absorb and release moisture too slowly to sustain good tree growth. Species suitable for planting are such conifers as eastern redcedar, ponderosa pine, Austrian pine, and Scotch pine.

WINDBREAK SUITABILITY GROUP 10

In this group are soils and land types that have a wide range of characteristics. Included are very shal-

low to shallow soils over hard limestone and shale, steep and very steep soils, deeply dissected and gullied uplands, frequently flooded bottom lands, and very poorly drained bottom lands. The soil material ranges from silt loam to clay.

The soils of this group are generally not suitable for windbreak plantings. Tolerant species can be hand planted in a few areas if special practices are used. These areas can then be used as recreation areas or as wildlife habitat.

Use of the Soils for Wildlife and Recreation ⁵

The type of wildlife that inhabit an area is determined largely by the kind and amount of vegetation the soils support. Adequate cover, food, and water are necessary for abundant wildlife. Such soil characteristics as fertility, relief, permeability, wetness, and available water capacity affect the suitability of soils for use as habitat for both game and nongame species of wildlife.

Because they produce more nutritious food plants, fertile soils support healthier wildlife than infertile soils. Often, however, fertile soils having high potential for use as wildlife habitat do not have a large wildlife population because hunting reduces the population and clean tillage and certain harvesting methods reduce the food available. Proper management increases the population with little expenditure of money and effort.

Ponds filled by runoff from fertile fields generally produce more fish because the microscopic plants and animals produced in fertile ponds are consumed by larger aquatic animals, such as frogs, which are, in turn, used as food by fish.

Steep, rough, and irregular soils are not suitable for grazing livestock or cultivated crops. These areas can be used as cover and food for wildlife. If vegetation is lacking, trees and shrubs that produce flowers and fruit can be planted. Examples of adapted trees are oak, red mulberry, redbud, hackberry, black locust, honeylocust, eastern cottonwood, willow, black walnut, elderberry, native plum, hawthorn, chokecherry, and osageorange. Suitable legumes are partridgepea, vetch, and red clover. Suitable grasses are big bluestem, little bluestem, switchgrass, and reed canarygrass.

Wetness, permeability, and available water capacity are important soil characteristics to consider when selecting sites for ponds. Most of the soils in Pawnee County are clayey and have slow or moderately slow permeability, but a few have moderate permeability.

The farm ponds or watershed impoundments in the county provide good fishing for bass, bluegill, and channel catfish. Burchard Lake, located east of Burchard, provides good fishing for largemouthed bass, black crappie, and channel catfish. The lake is stocked and managed by the Nebraska Game and Parks Commission. A recreation area having designated camping and picnic sites is also operated and maintained by the Commission at Burchard Lake.

The North Fork and South Fork of Big Nemaha

River provide warm-water stream fishing in Pawnee County. Bait fish are produced in many of the tributaries of the Big Nemaha River.

The activity of man in parts of Pawnee County has changed the variety of wildlife species. When the hills and valleys were covered with grass, such range wildlife as prairie grouse prevailed. As the native range became cultivated, the habitat for range wildlife diminished. Only a few protected flocks of prairie grouse still remain in the county in several large areas of native range. Bobwhite quail and ring-necked pheasant benefited greatly from the conversion of range to cultivated crops. Both species inhabit areas of cropland, grassland, and woody or rank-growing herbaceous vegetation. Bobwhite quail are a native species. Ring-necked pheasant were introduced from China in 1881.

Many species of songbirds are throughout the county. They inhabit areas where herbaceous plants, flowering and fruit-bearing trees, shrubs, and vines provide food and cover. The largest concentrations are around water.

The potential of the soil associations in the county for producing habitats needed for openland, woodland, and wetland wildlife is given in table 4. For the locations of the associations refer to the General Soil Map.

The highest elevations in the county are in the Wy-more association. Wildlife using the loess-capped uplands of this association are mainly upland game birds and deer. Pheasant are common. Most of these soils are cultivated, and the crop seeds and residue are used by wildlife. Erosion is slight to moderate.

The Pawnee-Mayberry-Burchard is the largest association in the county. The mixture of cropland and uncultivated areas provides a desirable habitat for both game and nongame species of wildlife (fig 24). The large areas of native range provide habitat for prairie grouse. The hazard of erosion and the texture of the soil are moderate to severe limitations that need to be considered when developing recreation areas on these soils.

The Kennebec-Judson-Wabash association supports abundant herbaceous and woody plants. These plants offer food and cover for most kinds of wildlife. The streams in this association are a good source of water. During dry periods water is available from succulent plants and dew. Such wetland wildlife as mink, weasel, and muskrat use this association as habitat.

The Benfield-Kipson-Sogn association consists of gently sloping to very steep soils in irregular strips bordering valleys. Shale and limestone bedrock crops out on the steepest parts of the association and on ledges. The association supports a variety of wildlife habitat. Important game species are deer, bobwhite quail, squirrel, and cottontail rabbit. Erosion is a severe hazard. Slope is a limitation that needs to be considered when developing recreation areas.

Openland wildlife are birds and mammals that normally live in and around cropland, pastures, meadows, lawns, and areas overgrown with grasses, herbs, and shrubby plants. Examples are ring-necked pheasant, bobwhite quail, songbirds, dove, cottontail rabbit, red fox, and coyote.

⁵ By ROBERT O. KOERNER, biologist, Soil Conservation Service.

TABLE 4.—*Suitability of principal soils for*

Soil association and series	Potential for—			
	Grain and seed crops	Domestic grasses and legumes	Wild herbaceous plants	Hardwood trees and shrubs
Wymore: Wymore.....	Good.....	Good.....	Fair: clayey subsoil.....	Fair: clayey subsoil.....
Pawnee-Mayberry-Burchard: Pawnee.....	Good to fair: 0 to 12 percent slopes.	Fair: clayey subsoil.....	Fair: clayey subsoil.....	Fair: clayey subsoil.....
Mayberry.....	Fair: 3 to 9 percent slopes.	Fair: clayey subsoil.....	Fair: clayey subsoil.....	Fair: clayey subsoil.....
Burchard.....	Fair: 5 to 17 percent slopes.	Good.....	Good.....	Fair: clayey loam subsoil.
Kennebec-Judson-Wabash: Kennebec.....	Good.....	Good.....	Good.....	Good.....
Judson.....	Good.....	Good.....	Good.....	Good.....
Wabash.....	Fair: poorly drained.....	Fair: poorly drained.....	Fair: poorly drained.....	Fair: poorly drained.....
Benfield-Kipson-Sogn: Benfield.....	Fair: 3 to 9 percent slopes; moderately deep.	Good.....	Good.....	Fair: clayey subsoil.....
Kipson.....	Poor: shallow.....	Poor: shallow.....	Fair: shallow.....	Fair: shallow.....
Sogn.....	Very poor: shallow.....	Poor: shallow.....	Poor: shallow.....	Poor: shallow.....

Woodland wildlife are birds and mammals that normally live in areas of hardwood trees and shrubs, coniferous trees and shrubs, or mixtures of such plants. Examples are fox squirrel, gray squirrel, white-tailed deer, raccoon, wild turkey, and opossum.

Wetland wildlife are birds and mammals that normally live in or around wet areas, such as ponds, marshes, and swamps. Examples are duck, geese, heron, shore birds, mink, muskrat, and beaver.

Developing good habitat for wildlife requires the proper location and distribution of vegetation. Technical assistance in planning wildlife developments and determining which species of vegetation to use can be obtained from the local office of the Soil Conservation Service, from the Nebraska Game and Parks Commission, the Bureau of Sport Fisheries and Wildlife, and from the Federal Extension Service. The Soil Conservation Service also provides technical assistance in planning and applying conservation practices for developing outdoor recreation facilities.

Engineering Uses of the Soils ⁶

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

⁶ MARVIN D. KEEBLER, engineer, Soil Conservation Service, assisted in the preparation of this section.

Among properties of soils highly important in engineering are permeability, shear strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction (pH). Also important are depth to the water table, depth to bedrock, and soil slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternative routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built to predict performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

elements of wildlife habitat and kinds of wildlife

Potential for—Continued			Kinds of wildlife		
Coniferous plants	Wetland food and cover plants	Shallow water developments	Openland wildlife	Woodland wildlife	Wetland wildlife
Fair: clayey subsoil.....	Poor: moderately well drained.	Very poor: moderately well drained.	Good.....	Fair.....	Very poor.
Fair: clayey subsoil.....	Very poor: moderately well drained.	Very poor: moderately well drained.	Fair.....	Fair.....	Very poor.
Fair: clayey subsoil.....	Very poor: 3 to 9 percent slopes.	Very poor: 3 to 9 percent slopes.	Fair.....	Fair.....	Very poor.
Good.....	Very poor: 5 to 17 percent slopes.	Very poor: 5 to 17 percent slopes.	Fair.....	Fair.....	Very poor.
Fair: subject to flooding..	Poor: moderately well drained.	Very poor: moderately well drained.	Good.....	Fair.....	Very poor.
Good.....	Very poor: well drained.	Very poor: well drained.	Good.....	Good.....	Very poor.
Fair: poorly drained.....	Good.....	Good.....	Fair.....	Fair.....	Good.
Good.....	Very poor: 3 to 9 percent slopes.	Very poor: well drained; 3 to 9 percent slopes.	Fair.....	Fair.....	Very poor.
Fair: shallow.....	Very poor: 5 to 60 percent slopes.	Very poor: somewhat excessively drained; 5 to 60 percent slopes.	Poor.....	Fair.....	Very poor.
Poor: shallow.....	Very poor: 12 to 60 percent slopes.	Very poor: somewhat excessively drained; 12 to 60 percent slopes.	Poor.....	Poor.....	Very poor.

Most of the information in this section is presented in tables 5, 6, and 7. These tables show, respectively, engineering test data, estimated soil properties significant in engineering, and interpretations of engineering properties.

The information in this section, along with the soil maps and other parts of this publication, can be used to make interpretations in addition to those given in tables 6 and 7, and it also can be used to make other useful maps. This information is not intended for use in design and does not eliminate the need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables (generally depths of more than 6 feet). Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists but are not known to all engineers. Many of these terms commonly used in soil science are defined in the Glossary.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (8) used by SCS engineers, Department of Defense, and others, and the AASHO system (1) adopted

by the American Association of State Highway Officials.

The Unified system is used to classify soils according to engineering uses for building material or for the support of structures other than highways. Soils are classified according to particle-size distribution, plasticity index, liquid limit, and content of organic matter. Soils are grouped into 15 classes. Eight classes of coarse-grained soils are subdivided on the basis of the content of gravel and sand. These are identified as GW, GP, GM, GC, SW, SP, SM, and SC. Six classes of fine-grained soils are subdivided on the basis of the plasticity index. Nonplastic classes are ML, MH, OL, and OH; plastic classes are CL and CH. Also, one class of highly organic soils, Pt, is included in the Unified system. Soils on the borderline between two classes are designated by symbols for both classes; for example, CL-ML.

The AASHO system is used to classify soils according to those properties that affect their use in highway construction and maintenance. In this system a soil is placed in one of seven basic groups, ranging from A-1 through A-7, on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A-7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b,



Figure 24.—A desirable mixture of habitat requirements for wildlife is present in the Pawnee-Mayberry-Burchard soil association.

A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, and A-7-6. As additional refinement, the engineering value of a soil can be indicated by a group index number. Group index numbers range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in Table 5; the estimated classification, without group index numbers, is given in table 6 for all soils mapped in the survey area.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter. "Sand," "silt," "clay," and some of the other terms used in the USDA textural classification are defined in the Glossary. If stones, cobblestones, or gravel are in the soil, this is indicated by the appropriate textural modifier.

Soil test data

Table 5 contains engineering test data for soils in some of the major series in Pawnee County. These tests were made to help evaluate the soils for engineering uses. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at

successively higher contents of moisture, assuming that the compactive effort remains constant, the density of the compacted material increases until the optimum moisture content is reached. After that, density decreases with increase in the content of moisture. The highest dry density obtained in the compactive test is termed maximum dry density. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material. The plasticity index is the numerical difference between the liquid limit and the plastic limit.

Soil properties significant to engineering

Estimated soil properties significant to engineering are given in table 6. These estimates are made for representative soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made during the survey, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Explanations of some of the columns in table 6 are presented in the following paragraphs.

Depth to bedrock is the distance from the surface of the soil to a rock layer within the 120-inch observation depth used during this survey.

Depth to seasonal high water table is the distance

from the surface of the soil to the highest level that ground water reaches in most years.

Soil texture is described in table 6 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in the soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added; for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary.

Liquid limit and plasticity index are water contents obtained by specified operations. As the content of moisture of a clayey soil, from which the particles coarser than 0.5 millimeter have been removed, is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from a semisolid to a plastic state; and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of water content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 6, but in table 5 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure, porosity, and texture. The estimates in table 6 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction refers to the acidity or alkalinity of a soil, expressed as a pH value of a stated soil-solution mixture. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. Soils having a high shrink-swell potential are the most hazardous. The shrink-swell potential is not indicated for organic soils or certain soils that shrink markedly on drying but do not swell quickly when rewetted.

Engineering interpretations of soils

The estimated interpretations in table 7 are based on the engineering properties of soils shown in table

5, on test data for soils in this survey area and others in nearby or adjoining areas, and on the experience of engineers and soil scientists with the soils of Pawnee County. In table 7, ratings are used to summarize limitations or suitability of the soils for all listed purposes other than for drainage of cropland and pasture, irrigation, ponds and reservoirs, embankments, and terraces and diversions. For these particular uses, table 7 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings *slight*, *moderate*, and *severe*. *Slight* means soil properties are generally favorable for the rated use, or, in other words, the limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation, special designs, or intensive maintenance. For some uses, the rating of severe is divided to obtain ratings of severe and very severe. Very severe means one or more soil properties are so unfavorable for a particular use that overcoming the limitations is most difficult and costly and commonly is not practical for the rated use.

Soil suitability is rated by the terms *good*, *fair*, and *poor*, which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Explanations of some of the columns in table 7 are presented in the following paragraphs.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and has sides, or embankments, of compacted soil material. The assumption is made that the embankments are compacted to medium density and that the pond is protected from flooding. Properties are considered that affect the floor of the pond and the embankments. Those that affect the floor of the pond are permeability, content of organic matter, and slope; and if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankments, are the engineering properties of the embankment material, as interpreted from the Unified Soil Classification (8), and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, as for ex-

TABLE 5.—Engineering

[Tests performed by the Nebraska Department of Roads, in accordance with standard

Soil name and location	Parent material	Nebraska report number S—	Depth	Moisture-density ¹		Mechanical analysis ²				
				Maxi- mum dry density	Opti- mum mois- ture	Percentage passing sieve—				
						1½ in.	1 in.	¾ in.	½ in.	No. 4 (4.7 mm.)
			<i>In</i>	<i>Lb per cu ft</i>	<i>Pct</i>					
Burchard clay loam: 420 feet west and 400 feet north of the SE. corner of sec. 5, T. 2 N., R. 10 E. (Modal)	Glacial till.....	64-6594	0-13	96	22	-----	-----	-----	-----	-----
		64-6595	19-29	105	18	-----	100	98	97	95
		64-6596	37-50	108	18	-----	-----	100	99	98
Colo silty clay loam: 0.35 mile north and 420 feet east of the SW. corner of sec. 3, T. 2 N., R. 10 E. (Modal)	Alluvium.....	64-6597	0-7	99	20	-----	-----	-----	-----	-----
		64-6598	13-20	94	24	-----	-----	-----	-----	-----
		64-6599	30-54	100	20	-----	-----	-----	-----	-----
Mayberry clay loam: 170 feet south and 200 feet west of the NE. corner of sec. 29, T. 1 N., R. 11 E. (Modal)	Glacial till.....	34238	0-5	101	20	-----	-----	-----	-----	-----
		34239	19-28	96	23	-----	-----	-----	-----	-----
		34240	48-60	104	20	-----	-----	-----	-----	-----
Morrill loam: 420 feet west and 50 feet south of the NE. corner of the SE¼ of sec. 28, T. 2 N., R. 12 E. (Modal)	Glacial lacustrine deposits over limestone and shale.	64-6600	0-12	105	16	-----	-----	-----	-----	-----
		64-6601	20-30	109	16	-----	-----	100	99	99
		64-6602	30-40	113	14	-----	-----	-----	100	99
		64-6603	40-50	115	14	-----	-----	-----	-----	100
Pawnee clay loam: 0.3 mile west and 350 feet south of the NE. corner of sec. 2, T. 2 N., R. 11 E. (Modal)	Glacial till.....	34229	0-6	104	19	-----	-----	-----	-----	-----
		34230	14-24	95	25	100	99	99	97	95
		34231	53-63	105	20	-----	-----	-----	-----	-----
Wabash silty clay loam: 500 feet east and 160 feet south of the center of sec. 21, T. 2 N., R. 11 E. (Modal)	Alluvium.....	34253	0-7	98	21	-----	-----	-----	-----	-----
		34254	13-22	90	28	-----	-----	-----	-----	-----
		34255	55-60	96	25	-----	-----	-----	-----	-----
Wymore silty clay loam: 1,170 feet west and 580 feet south of the NE. corner of sec. 1, T. 1 N., R. 11 E. (Modal)	Loess.....	34214	0-5	95	23	-----	-----	-----	-----	-----
		34215	17-25	98	27	-----	-----	-----	-----	-----
		34216	53-63	112	16	-----	-----	-----	-----	-----

¹ Based on AASHTO Designation T 99-47, Method A (1).² Mechanical analysis, according to AASHTO Designation T 88-47 (1). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method and the various grain-sized fractions are calculated on the basis of all the material including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the

test data

procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis ² —Continued								Liquid limit	Plasticity index	Classification	
Percentage passing sieve—Continued				Percentage smaller than—						AASHO ³	Unified ⁴
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 60 (0.25 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
100 93 95	95 85 88	88 80 83	66 69 72	62 66 66	52 58 60	32 36 42	25 30 32	46 46 44	22 24 24	A-7-6(12) A-7-6(14) A-7-6(14)	CL CL CL
100 100 100	95 99 98	88 98 94	81 91 87	73 84 79	58 63 62	36 40 39	30 34 33	45 44 44	19 19 22	A-7-6(13) A-7-6(12) A-7-6(14)	ML-CL ML-CL CL
100 100 100	97 98 96	91 95 92	81 90 84	76 87 81	54 66 61	32 47 41	29 43 36	40 59 48	18 34 28	A-6(11) A-7-6(20) A-7-6(17)	CL CH CL
100 99 99 99	98 96 95 97	96 95 93 95	64 57 41 38	57 52 37 31	41 43 30 26	34 27 23 19	20 24 21 17	30 32 30 22	11 14 14 5	A-6(6) A-6(6) A-6(6) A-4(1)	CL CL SC SM-SC
100 91 100	96 86 94	91 83 88	80 76 76	76 73 72	54 61 56	33 48 42	28 44 36	34 66 53	12 39 33	A-6(9) A-7-6(20) A-7-6(19)	ML-CL CH CH
-----	100	99 100	98 99 100	96 97 98	75 80 85	44 58 61	36 48 49	44 71 71	19 40 43	A-7-6(12) A-7-5(20) A-7-6(20)	ML-CL CH CH
-----	-----	-----	100	97	68	39	35	42	18	A-7-6(12)	ML-CL
-----	-----	-----	100	98	78	51	44	68	39	A-7-6(20)	CH
100	97	93	86	84	63	36	30	38	19	A-6(12)	CL

material coarser than 2 millimeters in diameter is excluded from calculations of grain-sized fractions. The mechanical analysis data used in this table are not suitable for use in naming textural classes for soil.

³ Based on AASHO Designation M 145-49.

⁴ Based on the Unified Soil Classification System, Technical Memo No. 3-357.

TABLE 6.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such to other series that appear in the first column

Soil series and map symbols	Depth to—		Depth from surface	Classification		
	Bedrock	Seasonal high water table		USDA texture	Unified ¹	AASHO
	<i>Inches</i>	<i>Feet</i>	<i>Inches</i>			
Benfield:						
BbC2-----	20-40	>20	0-14 14-35 35-39	Silty clay loam----- Silty clay----- Silty clay loam-----	CL or ML-CL CH or CL CL or CH	A-7 or A-6 A-7 A-7
BcC3-----	20-40	>20	39-60 0-25 25-35 35-60	Silty and clayey shale. Silty clay----- Silty clay loam----- Silty and clayey shale.	CH or CL ML-CL or CL	A-7 A-7
Burchard: BdD, BdE-----	>120	>20	0-13 13-60	Clay loam----- Clay loam-----	CL CL	A-7 or A-6 A-7
Butler: Bu-----	>120	>20	0-12 12-34 34-60	Silt loam----- Silty clay----- Silty clay loam-----	ML or CL CH CL or CH	A-6 or A-4 A-7 A-6 or A-7
*Colo: Ck----- For Kennebec part of Ck, see Kennebec series.	>120	3-8	0-13 13-60	Silty clay loam----- Silty clay loam-----	CL or ML-CL CL, CH, or ML-CL	A-7 or A-6 A-7
Crete: Cr-----	>120	>20	0-10 10-19 19-38 38-60	Silt loam----- Silty clay loam----- Silty clay----- Silty clay loam-----	ML-CL or CL CL CH CL	A-6 or A-4 A-7 or A-6 A-7 A-7 or A-6
Judson: JuC-----	>120	10-20	0-16 16-33 33-58	Silt loam and light silty clay loam. Silty clay loam----- Silty clay loam-----	ML or CL CL or CH CL	A-6 or A-7 A-7 or A-6 A-7 or A-6
Kennebec: Ke-----	>120	8-20	0-30 30-60	Silt loam----- Silt loam and loam-----	ML-CL or CL CL	A-6 or A-7 A-6 or A-7
*Kipson: KfE, KsF----- For Benfield part of KfE, see Benfield series. For Sogn part of KsF, see Sogn series.	10-20	>20	0-17 17-36	Silty clay loam with lime- stone fragments. Interbedded silty and clayey shale.	CL	A-7
Malcolm: McD, McF-----	>120	>20	0-10 10-35 35-60	Silt loam and light silty clay loam. Silty clay loam----- Stratified silt loam, very fine sandy loam, and silty clay loam.	ML to CL CL CL or ML	A-4 or A-6 A-6 A-6 or A-4
Mayberry:						
MdC-----	>120	>20	0-6 6-13 13-60	Loam----- Clay loam----- Clay-----	CL CL CH or CL	A-6 A-6 or A-7 A-7
MeC2, MfC3-----	>120	>20	0-13 13-60	Clay loam----- Clay-----	CL CH or CL	A-6 A-7
Morrill:						
MrC, MrD, MrE-----	>120	>20	0-12 12-30 30-40 40-60	Loam----- Clay loam----- Sandy clay loam----- Sandy loam-----	CL CL or SC SC or CL SM or SM-SC	A-6 A-6 or A-7 A-6 A-4
MsD3, MsE3-----	>120	>20	0-20 20-40 40-60	Clay loam----- Sandy clay loam----- Sandy loam-----	CL or SC SC or CL SM or SM-SC	A-6 or A-7 A-6 A-4

significant to engineering

mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring of this table. The symbol > means more than]

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)						
						<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH</i>	
-----	-----	100	95-100	35-50	11-20	0.2-0.6	0.21-0.23	6.1-6.5	Moderate.
-----	-----	100	95-100	45-60	25-35	0.06-0.2	0.11-0.13	6.1-7.8	High.
-----	100	95-100	95-100	35-55	10-20	0.2-0.6	0.18-0.20	6.6-7.8	Moderate to high.
-----	-----	100	95-100	45-60	25-35	0.06-0.2	0.12-0.14	6.1-7.8	High.
-----	100	95-100	95-100	35-50	11-20	0.2-0.6	0.18-0.20	6.6-7.8	Moderate.
100	85-100	85-100	60-90	35-50	15-25	0.2-0.6	0.17-0.19	5.6-6.5	Moderate.
* 95-100	85-100	80-100	65-90	41-50	20-30	0.2-0.6	0.14-0.16	6.6-8.4	Moderate to high.
-----	100	97-100	95-100	20-35	5-20	0.6-2.0	0.22-0.24	6.1-6.5	Moderate.
-----	-----	100	95-100	55-70	40-55	0.06-0.2	0.11-0.13	6.6-7.3	High.
-----	100	97-100	95-100	35-55	20-35	0.2-0.6	0.18-0.20	7.9-8.4	Moderate to high.
-----	100	90-100	80-95	35-50	15-30	0.2-0.6	0.21-0.23	6.6-7.3	High.
-----	100	95-100	85-100	41-55	15-30	0.2-0.6	0.18-0.20	6.1-6.5	High.
-----	100	98-100	95-100	30-45	8-20	0.6-2.0	0.22-0.24	6.1-6.5	Moderate.
-----	100	98-100	95-100	30-50	11-20	0.02-0.6	0.18-0.20	6.1-6.5	Moderate to high.
-----	-----	98-100	98-100	50-65	25-40	0.06-0.2	0.11-0.13	6.6-7.8	High.
-----	100	98-100	96-100	36-50	15-30	0.2-0.6	0.18-0.20	7.4-7.8	Moderate to high.
-----	-----	100	95-100	30-45	14-20	0.6-2.0	0.22-0.24	6.1-6.5	Moderate.
-----	-----	100	97-100	35-52	20-30	0.2-0.6	0.18-0.20	6.1-7.3	Moderate to high.
-----	-----	100	95-100	35-50	20-30	0.2-0.6	0.18-0.20	6.6-7.3	Moderate.
-----	-----	100	95-100	35-45	15-25	0.6-2.0	0.22-0.24	6.1-6.5	Moderate.
-----	-----	100	95-100	35-45	15-25	0.6-2.0	0.20-0.22	6.5-7.3	Moderate.
* 70-100	70-100	65-95	70-90	35-50	11-20	0.2-0.6	0.21-0.23	7.9-8.4	Moderate to high.
100	95-100	90-100	85-100	15-30	8-20	0.6-2.0	0.22-0.24	5.6-6.0	Low to moderate.
100	95-100	95-100	85-100	20-35	5-15	0.6-2.0	0.18-0.20	6.1-6.5	Moderate.
100	95-100	65-95	80-95	15-35	4-20	0.6-2.0	0.17-0.19	6.6-7.3	Low to moderate.
100	95-100	90-100	75-95	30-45	11-20	0.6-2.0	0.20-0.22	5.6-6.0	Moderate.
-----	100	95-100	75-90	35-50	15-30	0.2-0.6	0.15-0.17	5.6-6.0	Moderate.
* 95-100	95-100	95-100	75-95	45-60	25-40	0.06-0.2	0.08-0.10	6.1-7.3	High.
-----	100	95-100	75-90	30-50	15-30	0.2-0.6	0.17-0.19	5.6-6.0	Moderate to high.
* 95-100	95-100	95-100	75-95	45-60	25-40	0.06-0.2	0.08-0.10	6.1-7.3	High.
100	95-100	90-100	55-80	25-35	11-20	0.6-2.0	0.20-0.22	5.6-6.0	Moderate.
* 95-100	90-100	80-100	45-65	25-45	11-25	0.2-0.6	0.15-0.17	5.6-6.0	Moderate.
* 85-100	70-100	70-98	36-60	20-35	11-20	0.2-0.6	0.15-0.17	6.1-6.5	Moderate.
* 85-100	65-100	60-98	36-45	15-30	5-10	2.0-6.0	0.11-0.13	6.1-6.5	Low.
* 95-100	90-100	80-100	40-65	25-45	11-25	0.2-0.6	0.17-0.19	5.6-6.0	Moderate.
* 85-100	70-100	70-98	36-60	20-35	11-20	0.2-0.6	0.16-0.18	6.1-6.5	Moderate.
* 85-100	65-100	60-98	36-45	15-30	5-10	2.0-6.0	0.11-0.13	6.1-6.5	Low.

TABLE 6.—*Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	Classification		
	Bedrock	Seasonal high water table		USDA texture	Unified ¹	AASHO
	<i>Inches</i>	<i>Feet</i>	<i>Inches</i>			
Pawnee:						
PaB, PaC	>120	>20	0-6	Loam.....	CL or ML-CL	A-6 or A-7
			6-14	Clay loam.....	CL or ML	A-6 or A-7
			14-53	Clay.....	CH	A-7
			53-60	Clay loam.....	CL or CH	A-7
PnC2, PsC3, PwD3.....	>120	>20	0-14	Clay loam.....	CL	A-6 or A-7
For Mayberry part of PwD3, see Mayberry series.			14-53	Clay.....	CH	A-7
			53-60	Clay loam.....	CL or CH	A-7
Rough broken and gullied land: Rg.....	>120	>20				
Too variable to rate.						
*Shelby: SbD, SkE.....	>120	>20	0-18	Clay loam.....	CL	A-7 or A-6
For Burchard part of SkE, see Burchard series.			18-60	Clay loam.....	CL	A-6 or A-7
Silty alluvial land: Sy.....	>120	>20				
Too variable to rate.						
*Sogn.....	5-20	>20	0-8	Silty clay loam.....	CL	A-6 or A-7
Mapped only with Kipson soils.			8-60	Limestone bedrock.		
Steinauer: StD, StF.....	>120	>20	0-9	Clay loam.....	CL	A-7 or A-6
			9-60	Clay loam.....	CL	A-6 or A-7
Wabash:						
Wa.....	>120	6-15	0-13	Silty clay loam.....	CL or ML-CL	A-6 or A-7
			13-60	Silty clay.....	CH	A-7
Ws.....	>120	6-15	0-60	Silty clay.....	CH	A-7
Wet alluvial land: Wx.....	>120					
Too variable to rate.						
Wymore:						
WyB, WyC, WyC2.....	>120	>20	0-13	Silty clay loam.....	CL or CH	A-6 or A-7
			13-40	Silty clay.....	CH	A-7
			40-60	Silty clay loam.....	CH or CL	A-7 or A-6
WzC3.....	>120	>20	0-40	Silty clay.....	CH	A-7
			40-60	Silty clay loam.....	CH or CL	A-7 or A-6

¹ If two or more classifications are shown, the classification listed first is the most common.

² 0 to 5 percent pebbles $\frac{3}{8}$ inch to 3 inches in diameter.

significant to engineering—Continued

Percentage less than 3 inches passing sieve—				Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)						
						<i>Inches per hour</i>	<i>Inches per inch of soil</i>	<i>pH</i>	
95-100	90-100	85-100	60-85	25-45	11-20	0.6-2.0	0.20-0.22	5.6-6.0	Moderate.
² 95-100	90-100	95-100	75-95	25-45	11-20	0.2-0.6	0.15-0.17	5.6-6.0	Moderate.
² 90-100	85-100	80-100	70-85	50-70	30-45	0.06-0.2	0.09-0.11	6.1-8.4	High.
² 95-100	90-100	85-95	65-85	41-60	25-40	0.2-0.6	0.14-0.16	7.9-8.4	Moderate to high.
² 95-100	90-100	95-100	75-95	25-45	11-20	0.2-0.6	0.17-0.19	5.6-6.0	Moderate.
² 90-100	85-100	80-100	70-85	50-70	30-45	0.06-0.2	0.09-0.11	6.1-8.4	High.
² 95-100	90-100	85-95	65-85	41-60	25-40	0.2-0.6	0.14-0.16	7.9-8.4	Moderate to high.
100	85-100	70-100	60-90	30-45	15-25	0.2-0.6	0.17-0.19	5.6-6.0	Moderate.
² 95-100	90-100	90-100	75-95	35-50	20-35	0.2-0.6	0.14-0.16	6.1-8.4	Moderate to high.
⁴ 70-95	75-95	75-85	60-85	30-45	11-25	0.2-0.6	0.21-0.23	6.6-7.3	Moderate to high.
² 85-100	85-95	75-90	60-90	30-45	15-25	0.2-0.6	0.17-0.19	7.9-8.4	Moderate.
² 95-100	90-100	85-100	70-95	35-50	15-35	0.2-0.6	0.15-0.17	7.9-8.4	Moderate.
-----	-----	100	95-100	35-50	15-25	0.2-0.6	0.21-0.23	6.1-6.5	Moderate.
-----	-----	100	95-100	55-75	25-50	0.06-0.2	0.11-0.13	5.6-7.8	High.
-----	-----	100	95-100	55-75	25-50	0.06-0.2	0.11-0.13	5.6-7.8	High.
-----	-----	100	95-100	35-55	15-25	0.2-0.6	0.21-0.23	5.6-6.0	Moderate to high.
-----	-----	100	95-100	50-75	35-45	0.06-0.2	0.11-0.13	6.1-7.3	High.
-----	100	95-100	80-100	35-55	15-25	0.2-0.6	0.18-0.20	6.6-7.3	Moderate to high.
-----	-----	100	95-100	50-75	35-45	0.06-0.2	0.12-0.14	5.6-7.3	High.
-----	100	95-100	80-100	35-55	15-25	0.2-0.6	0.18-0.20	6.6-7.3	Moderate to high.

² 0 to 20 percent limestone fragments more than 3 inches in diameter.⁴ 10 to 20 percent limestone fragments more than 3 inches in diameter.

TABLE 7.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such to other series that appear

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
Benfield: BbC2, BcC3----	Severe: slow permeability; silty and clayey shale at depth of 20 to 40 inches.	Severe: silty and clayey shale at depth of 20 to 40 inches.	Moderate: silty and clayey shale at depth of 20 to 40 inches.	Severe: high shrink-swell potential; silty and clayey shale at depth of 20 to 40 inches.	Severe: silty and clayey shale at depth of 20 to 40 inches.	Severe: high shrink-swell potential; silty and clayey shale at depth of 20 to 40 inches; moderate to high potential for frost action.
Burchard: BdD, BdE-----	Severe: moderately slow permeability; slopes.	Moderate where slopes are less than 7 percent. Severe where slopes are more than 7 percent.	Moderate: clay loam.	Severe: moderate to high shrink-swell potential; moderate potential for frost action; slopes.	Moderate: clay loam.	Moderate: moderate to high susceptibility to frost action; extreme relief requires deep cuts and high fills in places.
Butler: Bu-----	Severe: slow permeability.	Slight-----	Severe: somewhat poorly drained.	Severe: high shrink-swell potential; high potential for frost action; plastic.	Severe: clayey.	Severe: high susceptibility to frost action; plastic; surface ponding; minimum slopes needed in places; poor workability.
*Colo: Ck----- For Kennebec part of Ck, see Kennebec series.	Severe: moderately slow permeability; occasional flooding.	Severe: occasionally flooded.	Severe: occasionally flooded; somewhat poorly drained.	Severe: high shrink-swell potential; high potential for frost action; plastic; occasional flooding.	Severe: silty clay loam; somewhat poorly drained; water table at depth of 3 to 8 feet; occasionally flooded.	Severe: high susceptibility to frost action; occasional flooding or ponding; minimum fill needed in places; high shrink-swell potential.
Crete: Cr-----	Severe: slow permeability.	Slight-----	Moderate: moderately well drained; silty clay subsoil.	Severe: high shrink-swell potential; plastic; moderate to high potential for frost action.	Moderate to severe: clayey.	Severe: moderate to high susceptibility to frost action; plastic subsoil; moderate to high shrink-swell potential.

engineering properties of the soils

mapping units may have different properties and limitations, and for this reason, it is necessary to follow carefully the instructions for referring in the first column of this table]

Suitability as source of—		Soil features affecting—				
Road fill	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of crop-land and pasture	Irrigation	Terraces and diversions
Poor: high shrink-swell potential; plastic.	Fair in top 14 inches of un-eroded areas; slopes; shale at depth of 20 to 40 inches.	Moderate to low seepage; silty and clayey shale at depth of 20 to 40 inches; slow permeability.	Good to poor stability; fair to poor workability; impervious; medium to high compressibility; slopes erodible; cracks when dry.	Well-drained; slow permeability; medium to rapid surface runoff; silty and clayey shale at depth of 20 to 40 inches.	Moderate available water capacity; moderately deep soil over shale; slow permeability; erodible; limited water supply.	Erodible; silty to clayey shale at depth of 20 to 40 inches; gently sloping to moderately steep.
Poor: moderate to high shrink-swell potential; moderately plastic.	Fair: clay loam.	Low seepage; moderately slow permeability.	Good to fair stability; good to fair workability; medium to high compressibility.	Well drained; moderately slow permeability.	High available water capacity; moderately sloping to moderately steep; most areas not suited because of slope; limited water supply.	Erodible; moderately sloping to moderately steep.
Poor: moderate to high shrink-swell potential; plastic subsoil.	Good in top 12 inches. Poor below depth of 12 inches; too clayey.	Low seepage; suitable in places for excavated ponds; slow permeability; nearly level.	Fair to good stability; impervious; medium to high compressibility; fair to poor workability.	Slow internal and surface drainage; adequate outlets not available in places.	High available water capacity; slow intake rate; slow runoff; nearly level topography.	Terraces not needed; diversion slopes erodible; nearly level; clayey subsoil; outlets not readily available in places.
Poor: plastic; high shrink-swell potential; high susceptibility to frost action.	Fair: silty clay loam.	Low seepage; suitable for excavated ponds; moderately slow permeability; nearly level; water table at depth of 3 to 8 feet.	Fair to good stability; fair to poor workability; cracks when dry.	Slow surface drainage; subject to occasional over-flow; adequate outlets not available in places; moderately slow permeability; water table at depth of 3 to 8 feet.	High available water capacity; moderately slow intake rate; water table at depth of 3 to 8 feet; somewhat poorly drained.	Terraces not needed; diversion slopes erodible.
Poor: high shrink-swell potential; plastic; high susceptibility to frost action.	Good in top 10 inches. Fair between depths of 10 and 19 inches. Poor below depth of 19 inches; too clayey.	Low seepage; suitable for excavated ponds; slow permeability; nearly level to very gently sloping.	Fair to good stability; impervious; fair to poor workability; medium to high compressibility.	Moderately well drained; slow permeability; slow runoff.	High available water capacity; slow intake rate; deep soil; slow permeability.	Erodible; clayey subsoil; slow permeability.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
Judson: JuC-----	Severe: moderately slow permeability.	Slight where slopes are less than 2 percent. Moderate where slopes are more than 2 percent.	Slight to moderate: low sidewall stability.	Severe: moderate to high shrink-swell potential; moderate to high potential for frost action.	Moderate: silty clay loam.	Severe: moderate to high susceptibility to frost heave; erodible slopes; moderate to high shrink-swell potential.
Kennebec: Ke-----	Severe: occasional flooding.	Severe: occasional flooding.	Severe: occasional flooding.	Severe: occasionally flooded; high potential for frost action.	Severe: occasional flooding.	Severe: high susceptibility to frost action; erodible slopes; occasional flooding.
*Kipson: KfE, KsF----- For Benfield part of KfE, see Benfield series. For Sogn part of KsF, see Sogn series.	Severe: silty and clayey shale at depth of 10 to 20 inches.	Severe: silty and clayey shale at depth of 10 to 20 inches.	Moderate: to clayey shale at depth of 10 to 20 inches. Severe where slopes are more than 15 percent.	Severe: silty and clayey shale at depth of 10 to 20 inches.	Severe: silty and clayey shale at depth of 10 to 20 inches; some stones.	Severe: silty and clayey shale at depth of 10 to 20 inches.
Malcolm: McD, McF-----	Moderate: where slopes are less than 15 percent; moderate permeability. Severe where slopes are more than 15 percent.	Moderate where slopes are less than 7 percent. Severe where slopes are more than 7 percent.	Moderate where slopes are less than 15 percent. Severe where slopes are more than 15 percent. Low sidewall stability.	Moderate: moderate potential frost action. Severe where slopes are more than 15 percent.	Slight where slope is less than 15 percent. Moderate where slopes are 15 to 25 percent. Silty clay loam mixed with sandy loam in lower part.	Moderate: moderate shrink-swell potential. Severe where slopes are more than 15 percent; require deep cuts and high fills in places.
Mayberry: MdC, MeC2, MfC3.	Severe: slow permeability.	Moderate where slopes are less than 7 percent. Severe where slopes are more than 7 percent.	Severe: clayey material to depth of more than 5 feet.	Severe: high shrink-swell potential; plastic.	Severe: clayey.	Severe: clayey soil material with high shrink-swell potential; erodible.
Morrill: MrC, MrD, MrE, MsD3, MsE3.	Severe: moderately slow permeability; slopes.	Moderate where slopes are less than 7 percent. Severe where slopes are more than 7 percent.	Moderate: clay loam to depth of about 30 inches; slopes are more than 8 percent in places.	Moderate: moderate shrink-swell potential; moderate potential for frost action; slopes.	Slight-----	Moderate where slopes are more than 8 percent; moderate shrink-swell potential; erodible.
Pawnee: PaB, PaC, PnC2, PsC3, PwD3.	Severe: slow permeability; slopes.	Moderate where slopes are less than 7 percent. Severe where slopes are more than 7 percent.	Severe: clayey material to depth of about 4.5 feet.	Severe: high shrink-swell potential; poor bearing capacity.	Severe: clayey.	Severe: high shrink-swell potential; plasticity hinders hauling.
Rough broken and gullied land: Rg. Too variable to rate.						

properties of the soils—Continued

Suitability as source of—		Soil features affecting—				
Road fill	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of crop-land and pasture	Irrigation	Terraces and diversions
Poor: moderate to high shrink-swell potential; plastic.	Good in top 8 inches. Fair below depth of 8 inches; silty clay loam.	Low to moderate seepage; very gently sloping to gently sloping.	Fair to good stability; fair to good workability; medium compressibility.	Well drained; moderately slow permeability.	High available water capacity; deep soil; very gently sloping to gently sloping; moderately slow permeability.	Erodible; very gently sloping to gently sloping; moderately slow permeability.
Fair to poor: moderate shrink-swell capacity; high susceptibility to frost action.	Good-----	Moderate seepage; nearly level; water table at depth of 8 to 20 feet.	Good to poor stability; good to fair workability; medium compressibility.	Moderately well drained; slow surface runoff; infrequent flooding.	High available water capacity; moderate permeability; nearly level slope.	Terraces not needed; diversion slopes erodible; outlets not available in places.
Poor: only small amount of moderately plastic soil.	Poor: limited amount of material; underlain by shale at shallow depth.	Moderate seepage in limestone fragments; moderately sloping to very steep.	Fair stability; poor workability; rock fragments; limited borrow.	Moderately slow internal drainage; silty and clayey shale at depth of 10 to 20 inches; moderately sloping to very steep.	Not suited: slope; shallow soil.	Erodible; shallow over shale; moderately sloping to very steep.
Fair: moderate shrink-swell potential.	Good in top 10 inches. Fair in subsoil. Poor where slopes are more than 15 percent.	Moderate seepage; moderately sloping to steep.	Fair to good stability and workability; drains needed in places; medium compressibility.	Well drained; runoff is medium to rapid.	Most areas not suited: slope; limited water supply.	Erodible; moderately sloping to steep; moderate permeability.
Poor: high shrink-swell potential; clayey.	Fair in top 10 inches of uneroded areas. Poor in subsoil.	Low seepage; gently sloping to strongly sloping; slow permeability.	Erodible slopes; good to fair stability; fair to poor workability; medium to high compressibility.	Well-drained surface; poor internal drainage; clayey subsoil.	Moderate available water capacity; slow permeability; some areas too steep; limited water supply.	Erodible; clayey subsoil; slow permeability; gently sloping to strongly sloping.
Good to fair: moderate shrink-swell potential.	Good in upper 12 inches of uneroded areas. Fair in subsoil.	Generally low seepage; gently sloping to moderately steep.	Erodible slopes; fair stability and workability; low to medium compressibility.	Well drained; moderately slow permeability; medium to rapid runoff.	High available water capacity; moderately slow permeability. Some areas not suited: slope; limited water supply.	Erodible; gently sloping to moderately steep.
Poor: high shrink-swell potential; clayey; plastic.	Good to fair in top 10 inches of uneroded areas. Poor in subsoil.	Low seepage; slow permeability; nearly level to strongly sloping; high shrink-swell potential.	Fair to poor stability; cracks when dry; fair to poor workability; medium to high compressibility; low shear strength.	Moderately well drained; slow permeability; nearly level to strongly sloping.	Moderate available water capacity; slow permeability. Some areas not suited: slope; limited water supply.	Erodible; clayey subsoil; poor workability of subsoil; nearly level to strongly sloping.

TABLE 7.—*Interpretations of engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Local roads and streets
*Shelby: SbD, SkE----- For Burchard part of SkE, see Burchard series.	Severe: moderately slow permeability.	Moderate where slopes are less than 7 percent. Severe where slopes are more than 7 percent.	Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Moderate to severe: moderate shrink-swell potential; plastic; slopes.	Moderate: clay loam.	Severe: moderate shrink-swell potential; moderate to high susceptibility to frost action; plastic; slopes.
Silty alluvial land: Sy-----	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.
Sogn----- Mapped only with Kipson soils.	Severe: limestone at depth of 5 to 20 inches.	Severe: limestone at depth of 5 to 20 inches; slopes.	Severe: hard limestone at depth of 5 to 20 inches; slopes.	Severe: hard limestone at depth of 5 to 20 inches; slopes.	Severe: hard limestone bedrock at depth of 5 to 20 inches; slopes.	Severe: hard limestone bedrock at depth of 5 to 20 inches; slopes.
Steinauer: StD, StF-----	Severe: moderately slow permeability; slopes.	Severe: slopes.	Moderate where slopes are 8 to 15 percent. Severe where slopes are more than 15 percent.	Moderate: moderate shrink-swell potential. Severe where slopes are more than 15 percent.	Moderate: clay loam soil material; slopes are more than 15 percent in places.	Moderate: moderate shrink-swell potential; moderate susceptibility to frost action. Severe where slopes are more than 15 percent.
Wabash: Wa, Ws-----	Severe: slow permeability.	Slight, but may require protection from overflow.	Severe: commonly clayey to depth of more than 5 feet; poorly drained.	Severe: poor bearing capacity in places; poorly drained; high shrink-swell potential.	Severe: clayey soil; periodic flooding; poorly drained; poor workability.	Severe: high shrink-swell potential; plastic; poorly drained.
Wet alluvial land: Wx. Too variable to be rated.						
Wymore: WyB, WyC, WyC2, WzC3.	Severe: slow permeability.	Slight where slopes are less than 2 percent. Moderate where slopes are 2 to 7 percent.	Severe: clayey soil material to depth of about 40 inches.	Severe: shrink-swell potential; fair to poor bearing capacity in places.	Severe: clayey.	Severe: high shrink-swell potential; plastic; erodible.

properties of the soils—Continued

Suitability as source of—		Soil features affecting—				
Road fill	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: moderate shrink-swell potential.	Fair in top 12 inches; clay loam. Poor in subsoil.	Low seepage; moderately slow permeability; moderately steep.	Good to fair stability; impervious; fair workability; erodible slopes; medium to low compressibility.	Moderately well drained; fair to good internal drainage; rapid runoff; moderately slow permeability.	Not suited: slopes.	Erodible: moderately steep.
Poor: poorly drained; frequently flooded.	Poor to good depending on wetness and accessibility.	Moderate seepage; channeling in most areas.	Fair to poor stability; fair to good workability; erodible slopes; toe drains needed in places.	Subject to frequent flooding; runoff slow in places; channeled.	Not suited: hazard of flooding.	Terraces not needed; diversion slopes erodible; frequently flooded.
Poor: shallow over hard limestone bedrock; slopes.	Poor: small quantity; slopes; stony; underlain by hard limestone at shallow depth.	High seepage in limestone bedrock; moderately steep to very steep; 5 to 20 inches deep over limestone bedrock.	Fair to poor stability; poor workability; rock fragments; limited borrow.	Slow internal drainage; medium to very rapid surface runoff; shallow over limestone.	Not suited: shallow soil; slope.	Slopes erodible; shallow over hard limestone; moderately steep to very steep.
Fair: moderate shrink-swell potential; slopes.	Fair in top 9 inches. Poor in subsoil; low fertility; high bulk density.	Low seepage; moderately slow permeability; moderately sloping to steep.	Fair to good stability; impervious; fair to poor workability; erodible slopes; medium to high compressibility.	Well drained; medium to rapid runoff; gently sloping to steep.	Most areas not suited: slope.	Erodible; moderately sloping to steep.
Poor: high shrink-swell potential; poorly drained.	Poor: poorly drained; clayey subsoil.	Low seepage; suitable for excavated ponds; water table at depth of 6 to 15 feet; nearly level.	Fair to poor stability; poor workability; erodible slopes; high compressibility; impervious; fair to poor compaction.	Slow internal drainage; surface runoff very slow or ponded; infrequent overflow; poorly drained.	Moderate available water capacity; very slow runoff; slow permeability; poorly drained.	Terraces not needed; diversion slopes erodible; poor workability; poorly drained; clayey.
Poor: high shrink-swell potential; clayey; plastic.	Fair in top 13 inches of un-eroded areas. Poor in clayey subsoil.	Low seepage; slow permeability; nearly level to moderately sloping.	Poor to good stability; impervious; fair to poor workability; medium to high compressibility; highly erodible; fair to poor compaction.	Slow to medium runoff; slow permeability; clayey subsoil.	Moderate available water capacity; slow permeability; nearly level to gently sloping; limited water supply.	Erodible; clayey subsoil; poor workability of subsoil; nearly level to gently sloping.

ample, excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings, as rated in table 7, are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to the capacity to support load and to resist settlement under load and those that relate to the ease of excavation. Soil properties that affect the capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 7 apply only to a depth of about 6 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet. Each site should be investigated before it is selected.

Local roads and streets, as rated in table 7, have an all-weather surface expected to carry automobile traffic throughout the year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHO and Unified classifications of the soil material, and also the shrink-swell potential, indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for roads. The suitability ratings reflect (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by the ease of working and spreading the soil material, as for preparing a seedbed; the

natural fertility of the soil or the response of plants when fertilizer is applied; and the absence of substances toxic to plants. The texture of the soil material and the content of stone fragments are characteristics that affect suitability. Also considered in the ratings is the damage that results at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and the depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soils that are resistant to seepage and piping and that have favorable stability, shrink-swell potential, shear strength, and compactibility. Stones and organic material in a soil are unfavorable factors.

Drainage of cropland and pasture is affected by such soil properties as permeability; texture; structure; depth to claypan, rock, or other layers that influence the rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity and alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, and soil blowing; texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; need for drainage; and the depth to a water table or bedrock.⁷

Terraces and diversions are embankments or ridges constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Sand and gravel are used in great quantities in many kinds of construction. These materials are not readily available in Pawnee County. In places, sand is below a depth of 3 feet in areas of Malcolm and Morrill soils. Gravel is not available in commercial quantities in the county.

Formation and Classification of Soils

In this section the factors that have affected formation of soils are described. Then the current system of soil classification is explained and each soil series is classified according to that system. The soil series in the county, including a profile representative of each series, are described in the section "Descriptions of the Soils."

⁷ Further information on soil use for irrigation is contained in the "Irrigation Guide for Nebraska," Soil Conservation Service, 1971.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineral composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material^s

The soils of Pawnee County formed in several kinds of parent material, such as recent alluvium, loess, water-deposited clay, silt, sand and gravel, glacial material, shale, and limestone. These materials differ in physical characteristics and in geologic age. The recent alluvium is the youngest material and the Pennsylvanian limestone and shale are the oldest. The age of parent material is not important in the formation of soil, but the mineral composition and physical properties are.

Soils inherit certain characteristics from the parent material. The pebbles, stones, and boulders in glacial soils; the broken stones in soils formed in weathered limestone; and the lack of pebbles and stones in loess soils are characteristics that are not lost or changed. Generally, soils that contain pebbles and grit are forming in parent material that is pebbly or gritty, and soils that have no pebbles and grit are forming in parent material that is free of this coarse sediment. In many instances, several kinds of soils develop from a single parent material. The soils differ from each other in the thickness, color, content of clay, and number and arrangement of soil horizons. The characteristics of each soil reflect the controlling factors in soil formation, slope and relief.

Geologic erosion has stripped most of the ancient soils from the landscape and exposed fresh parent ma-

terial for soil formation. The soils throughout the county do not differ greatly in the time that soil formation has been active. Soils forming in parent material that is a million years old have been forming for about the same length of time as the soils forming in the most recent loess, which is less than 20,000 years old.

The oldest geologic materials in which modern soils have formed are the Permian and Pennsylvanian limestones and shales. These materials were deposited in shallow seas 200 to 300 million years ago. They were buried under many feet of younger deposits but have been reexposed in areas bordering the valleys of the North Fork and South Fork of the Big Nemaha River and Turkey Creek in the eastern and southern parts of the county. They consist of ledges of somewhat hard limestone and of beds of calcareous, silty, and clayey shale. These materials weather to yellowish-brown, reddish-brown, or grayish-brown, clayey to silty material that contains shale and limestone fragments. Sogn, Kipson, and Benfield soils formed in this material on rolling slopes and valley sides of the larger drainageways and on a few ridgetops. The dominant vegetation is grasses or stands of mixed grasses, shrubby brush, and small trees.

The material left by the Nebraskan glacier overlies the shale and limestone. It is clayey till containing many limestone pebbles and cobblestones and a small amount of quartzitic sand and stone. The acreage of soils that formed in this material is small. Most of this material has been deeply covered by younger sediment, and only outcrops remain.

After the retreat of the Nebraskan glacier, the Fullerton age deposits of alluvial silt and fine sand were laid down. These buried deposits are preserved in upland areas of the northern, central, and western parts of the county. They are exposed on rolling slopes and are soil parent material principally in the north-central part of the country. Malcolm soils formed in the gray, clayey silt and fine sand. In places, remnants of the ancient Afton soil that formed in Fullerton material can be identified by the clay texture and dark color. The Afton soil is not significant to modern soil formation, although the sites of such outcrops are often slickspots, or thinly vegetated areas.

Kansan glacial materials were the next deposits spread over the county. Much of this material has been removed by erosion, and all of it has been washed from the places where older materials are exposed. In places, younger material covers the glacial deposits, but in most of Pawnee County the glacial material is at the surface. These deposits are the most extensive parent material in the county. The unoxidized and unweathered till is gray, but the till exposed in roadcuts and in the lower part of the soils is oxidized and weathered to grayish brown and contains yellowish-brown, strong-brown, and dark-brown iron stains and iron concretions. Cracks and seams are filled with soft, white lime.

The dominant parent material is the clayey glacial till that is a mixture of sand, silt, and clay. It contains numerous pebbles and occasional granite or quartzite boulders, and cobblestones. Thin layers and isolated

^s By JOHN A. ELDER, Conservation and Survey Division, University of Nebraska, Lincoln, Nebraska.

pockets of sand or sand and gravel are in the till, and the outcrops of this material are shown on the soil map by a sand-spot symbol.

Pawnee, Shelby, Burchard, and Steinauer soils formed in till, and they differ chiefly in the amount of clay in the subsoil and in the depth to which the lime has been leached. Pawnee and Shelby soils are more stable than the more sloping Burchard and Steinauer soils. The Burchard and Steinauer soils are mostly in drainage basins that have undergone recent downcutting and headward extension. Pawnee and Shelby soils are on the gently sloping ridgetops and on the smooth, sloping upper parts of valleys.

The ancient soil that developed on the till landscape, Yarmouth soil, is not present in outcrops or in test borings, suggesting that the soils that formed in the Kansan till were removed through erosion at the end of the Kansan age. The silt and clay were washed from the area, and the coarser material was left as pockets of gravel, fields of boulders, and as scattered gravel, stones, and boulders on the eroded surface. It was on this surface that the Illinoian material was deposited.

Illinoian material is throughout the county, but the tracts of soil that formed in this material are small. The material lies below Peoria loess and above glacial material, and it is exposed only on slopes. The reddish-brown soils contrast sharply with the yellowish-brown and grayish-brown soils that formed in Peoria loess and in Kansan glacial material. Mayberry soils formed in clayey sediment that contains sand, pebbles, and stones derived from glacial material in the area. Morrill soils formed in loamy sediment that contains many sand grains and a few pebbles. Loveland loess, which is late Illinoian, is thin and inextensive as parent material, and the small areas of soil formed in this material are included with the Mayberry and Morrill soils.

Peoria loess was the next soil parent material to be deposited. It is pale-brown to light olive-gray silty material that was carried to its present location by wind. It was deposited throughout the area but now remains only where erosion has been least active. These areas are nearly level and gently sloping ridges, hillsides, foot slopes, and stream benches and terraces. The large areas of Wymore soils and the small tracts of Butler soils formed in this material on uplands. Crete silt loam, terrace, formed in this material on low terrace positions. Judson soils commonly have loess below the subsoil.

The recent alluvium of the valleys is generally dark colored and consists of silty and clayey sediment washed from upland slopes and deposited on flood plains and valleys. Colo, Judson, Kennebec, and Wabash soils formed in this alluvial material. In places, the plains are occasionally flooded and fresh deposits continue to accumulate on these soils.

Climate

Climate is important in the formation of soils. During the last geologic period, the many climatic cycles influenced the shaping of the landscape and deposition of parent material in Pawnee County. Long periods of

moisture and cold activated glaciers that deposited glacial material. Dry and windy periods produced dust that accumulated as deposits of loess. Interspaced were stable periods of weathering and soil formation and periods of dissection and erosion.

Since deposition, the parent materials in Pawnee County have undergone marked changes in color, structure, and composition. These changes are caused mainly by leaching, oxidation, and other weathering processes; the accumulation of organic matter; the concentration of colloids and clay in the subsoil; and the partial removal of lime from the surface layer and upper subsoil. An example of the influence of climate on the present character of the soils in Pawnee County is seen in the uniform chemical composition of soils that formed on similar terrain but in different parent material. This uniformity has been brought about by a somewhat long period of weathering.

The parent materials originally varied in their content of free calcium carbonate. Leaching has removed most of the carbonates, as well as other soluble constituents, to a depth below the subsoil. Now, except for steep limy soils and areas of recent alluvium, most of the soils in Pawnee County have surface layers and upper subsoils that are medium to slightly acid. The soils in the county, however, retain a high percentage of the basic elements necessary for a fertile soil.

The climate in Pawnee County is fairly uniform, and local differences in soils cannot be attributed to differences in climate. Climate does cause differences in soils over broad regions. For example, in an area where the year-round climate is warm and humid the soils are more leached, are more acid, and contain less organic matter than soils in Pawnee County.

Climate affects weathering and soil formation through the kind and amount of rainfall received, the temperature, the humidity, and the nature of the winds. Climate also affects soil formation through its influence on the type and variety of plant and animal life. The effects of climate are modified by the parent material and the relief.

Plant and animal life

Plant and animal life have had a pronounced effect on the formation of soil in Pawnee County. The vegetation, determined by climate, is one of the most important factors in soil formation. Animals are important in the way they use and convert the vegetation.

One of the most striking and prevalent characteristics of the soils in Pawnee County is the dark color imparted by the large amount of organic matter. Prior to settlement, bluestem prairies dominated the landscape. The stems, leaves, and roots of the tall grasses produced the organic matter. As a result, a number of the soils have a deep, dark-colored, granular surface layer. The exceptions are the severely eroded soils and the soils most recently formed. The plants extracted calcium and other minerals from the lower part of the soil and returned them to the surface through their stems and leaves. This process renewed the upper part of the soil with basic elements. The penetration of fibrous grass roots also caused the dark colors to extend gradually into the subsoil.

Soils that are nearly level and gently sloping generally have a thicker, somewhat darker surface layer than steeper soils because they retained more moisture, had a better growth of grass, and lost less soil through erosion. Some soils on bottom lands are thick and dark because their parent alluvium was dark.

Micro-organisms, ants, earthworms, and burrowing rodents have a beneficial effect on soil structure, fertility, and productivity. Many kinds of micro-organisms convert organic remains into stable humus from which plants obtain nutrients. Earthworms and small burrowing animals influence the formation of soil by mixing the organic matter with minerals in the soil and by deepening the zone in which the organic matter accumulates. They also keep soils aerated and supply them with fresh minerals by bringing unleached parent material to the surface.

The activity of man also affects the formation of soil. Some of the effects are accelerated sheet and gully erosion, changes of the moisture regime through runoff and improved drainage, and the addition of plant nutrients and other soil amendments. In places, the activity of man has drastically changed the kinds of living organisms in the soil. Most of these changes affect soil development, but the effect of some of the changes may not be evident for centuries. Man can immediately change the soil by disturbing it, by adding chemicals, or by doing other things to make it suitable for his use.

Relief

Some difference among soils can be attributed to local variations in relief. Relief affects soil formation mainly through its effect on drainage and runoff. In this way, relief modifies the effect of climate. Runoff is more rapid on steep soils than on nearly level or gently sloping soils. Consequently, less water soaks into the soil and there is less leaching. Also, loss of soil through erosion is greater on steep soils. In these areas soil horizons are not distinct, and the solum is thin.

Relief and the position of soils in relation to water tables and runoff water are also important. Water tables and runoff water increase the moisture in soils, which in turn affects the kind and amount of vegetation on the soils.

The Wabash and Kennebec soils are nearly level, and surface runoff is slow. Runoff is rapid on such steep soils as the Sogn and Steinauer. Internal drainage, or permeability, is slow in soils that have a clayey subsoil, such as Pawnee, Mayberry, Wymore, and Wabash soils. Runoff is rapid on barren slopes.

Time

Differences in the time a soil has been affected by soil-forming processes are commonly reflected in the properties of the soil. If the parent material has been in place only a short time, the climate and vegetation have not had long to act and the soils lack well-defined horizons. Colo and Kennebec soils formed in recent alluvium, some of which was deposited during the last few centuries and some during the last few years, and they have no well-defined horizons.

The Butler, Crete, and Wymore soils developed in Peoria loess that had been in place long enough for well-defined, genetically related horizons to form. The Pawnee, Shelby, and Burchard soils, which formed in glacial till, and the Benfield soils, which formed in shale, also have well-defined horizons. Because they are somewhat steeply sloping, Steinauer and Kipson soils have been developing for a short period of time and are not leached of lime carbonate. The longer the parent material is exposed to soil development, the more nearly the soil reaches a balance with its environment. Under grass, a dark-colored surface layer develops in 100 to 150 years in the climate of Pawnee County. Several centuries are required to develop other genetically related horizons, such as those of the Mayberry, Wymore, and Pawnee soils.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (2, 5).

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are groups. The same property or subdivisions of this property may be used in several different categories. In table 8, the soil series of Pawnee County are placed in three categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. The three exceptions to this are the Entisols, Histosols, and Vertisols which occur in many different kinds of climate. The two orders in Pawnee County are Entisols and Mollisols. *Entisols* are light-colored

TABLE 8.—*Soil series classified according to the current system of classification*

[The classification shown is current as of August 1972. Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available]

Series	Family	Subgroup	Order
Benfield ¹	Fine, mixed, mesic	Udic Argiustolls	Mollisols.
Burchard	Fine-loamy, mixed, mesic	Udic Argiustolls	Mollisols.
Butler	Fine, montmorillonitic, mesic	Abruptic Argiaquolls	Mollisols.
Colo	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Crete	Fine, montmorillonitic, mesic	Pachic Argiustolls	Mollisols.
Judson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Kipson	Loamy, mixed, mesic, shallow	Udorthentic Haplustolls	Mollisols.
Malcolm	Coarse-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Mayberry ¹	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Morrill ¹	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Pawnee ¹	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.
Shelby	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Steinauer	Fine-loamy, mixed (calcareous), mesic	Typic Udorthents	Entisols.
Wabash	Fine, montmorillonitic, mesic	Vertic Haplaquolls	Mollisols.
Wymore ¹	Fine, montmorillonitic, mesic	Aquic Argiudolls	Mollisols.

¹ Unit BcC3 of Benfield series, MfC3 of Mayberry series, MsD3 and MsE3 of Morrill series, PsC3 and PwD3 of Pawnee series, and WzC3 of Wymore series are taxadjuncts to the series for which they are named. Their A horizon is thinner and lighter colored than defined in the range for the series.

soils that do not have natural genetic horizons or that have only very weakly expressed beginnings of such horizons. These soils do not have traits that reflect soil mixing caused by shrinking and swelling. *Mollisols* formed under grass and have a thick, dark-colored surface horizon that contains colloids dominated by bivalent cations. The soil material in these soils has not been mixed by shrinking and swelling.

SUBORDER. Each order is subdivided into suborders using those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than are the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth, soil climate, the accumulation of clay, iron, or organic carbon in the upper solum, cracking of soils caused by a decrease in soil moisture, and fine stratification.

GREAT GROUP. Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constituents have accumulated or have been removed; and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil composition, and soil color.

SUBGROUP. Great groups are subdivided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order.

FAMILY. Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils

when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence. An example is the coarse-loamy, mixed, mesic family of Typic Haplaquolls.

Physical and Chemical Analyses

Samples from soil profiles are collected for physical and chemical analyses by the Soil Conservation Service, Soil Survey Laboratory in Lincoln, Nebraska. Soils of the Pawnee, Wabash, and Wymore series were sampled in Pawnee County, and the data is published in Soil Survey Investigations No. 5 (7). The Mayberry soil was also sampled in Pawnee County, but the data are published under the name of "Adair." Data for profiles of Pawnee and Wymore soils sampled in Pawnee County are also published in the soil survey of Gage County, Nebraska (6). The Crete, Wymore, Burchard, and Morrill soils are in Pawnee County, But were sampled in nearby counties. Data for these soils are also published in Soils Investigations Report No. 5.

Laboratory data are useful to soil scientists in classifying soils and in developing concepts of soil genesis. It is helpful for estimating available water capacity, erosion potential, fertility level, ease of workability, and other practical aspects of soil management.

Environmental Factors Affecting the Use of Soils

In this section the chief natural and cultural features of Pawnee County that affect use and management of the soils are described. The section also provides information on the relief, physiography, drainage, climate, and water supply in the county.

Cultural features discussed are transport facilities, markets, schools, manufacturing facilities, and trends in farming.

Relief

Relief ranges from nearly level to very steep. Because of the headward advance of numerous small drainageways, the areas of nearly level uplands are small and, in places, irregular in outline. The most extensive upland areas are in the vicinity of Lewiston in the northwestern part of the county and on the north side of Mission Creek in the southwestern part of the county. The rest of the county comprises a succession of ridges, sloping areas, and valleys. The ridges are rounded and gently sloping, the slopes range from moderately sloping to very steep, and the bottoms of valleys are nearly level.

Long, gradual slopes on the north side of stream valleys and steep, short slopes on the south side of valleys are marked features of the uplands. The small drainageways are generally shallow. In places, however, they are sharply cut and have short, steep grades. The slopes along large streams are abrupt where they immediately border bottom lands and are gradual near the crests of divides. In most places, the slopes above the sides of valleys are moderate. The strongest slopes in the county are in bedrock uplands along the valleys of the North Fork and South Fork of the Big Nemaha River in the southeastern part of the county and in glacial uplands along the sides of Turkey Creek Valley. The bottom lands in the county range in width from a few rods along the smaller streams to about $1\frac{1}{2}$ miles along the North Fork of the Big Nemaha River.

The highest elevation in the county is on the nearly level upland divide near Lewiston in the Northwestern part of the county. The lowest elevation is along the North Fork of the Big Nemaha River southeast of Table Rock where the river crosses into Richardson County.

Physiography

Pawnee County lies entirely within the glaciated part of the Great Plains physiographic province. It is a thoroughly dissected glacial plain where only small remnants of the original till plain remain on the highest divides. The gently sloping, sloping, moderately steep, and steep landscape formed through geologic erosion of the glacial plain. Materials have been added and modified by cycles of sedimentation, erosion, and soil formation. Erosion formed the uplands, a few bench positions, and the continuous strips of bottom land.

The uplands, by far the most extensive of these features, are remnants of the original glacial till plain. Erosion has been so severe in places that the major streams cut deeply into the sedimentary limestone and shale bedrock. The exposed bedrock then became the parent material of soils in the southern and eastern parts of the county. In places, the till deposited by glaciers and the younger sediment have been completely

removed.

The few small benches in the county were once bottom lands that formed when streams were flowing at higher levels.

The strips of bottom land in the county include nearly all of the low-lying areas adjacent to streams where soil material is deposited. Some areas of bottom lands along creeks are subject to overflow. The channels of the North Fork and South Fork of the Big Nemaha River, however, have been artificially straightened and are deepening and eroding their valleys. The channel capacity has increased enough to minimize the hazard of stream overflow. A few of the tributaries of the rivers are deepening and widening their channels across the bottom lands and into the uplands.

Drainage

Drainage in Pawnee County is chiefly southeastward. The county has a large number of major and minor streams, each fed by many tributaries. The North Fork of the Big Nemaha River, the largest stream, flows southeastwardly across the northeastern part of the county and drains the east-central and northeastern parts of the county. Taylor Branch and Clear Creek are the largest tributaries of the North Fork. The South Fork of the Big Nemaha River flows northeastwardly across the southeastern part of the county. Its largest tributaries flow southeastwardly and drain most of the southeastern part of the county. The extreme northwestern part of the county and the central part of the county, from north to south, are drained by Turkey Creek and its western tributaries, which include Rock Creek, Balls Branch, West Branch, and Johnson Creek. Only the western and southwestern parts are drained westwardly. They are drained through Wolf Creek, Plum Creek, and Mission Creek to the Big Blue River in Gage County.

Nearly all of the main streams flow constantly, except during unusually prolonged droughts. All are somewhat swift, particularly at flood stage. The only poorly drained areas are the nearly level, fine-textured soils and the seepage areas along the outer edges of the valleys. The only excessively drained areas are the steep, shallow, and stony areas.

Climate ⁹

Pawnee County is in the extreme southeastern part of Nebraska. No bodies of water in the area are large enough to have an effect on the climate of the county. The county is near the center of the United States and, hence, has a continental climate. Changes in the weather are frequent and large. The county receives a favorable flow of moisture-laden air from the Gulf of Mexico and therefore escapes the extreme changes in weather experienced in other parts of Nebraska. The only recorded year having less than 20 inches of precipitation is 1956, which had 17.78 inches. Only about one year in ten has less than 23 inches.

⁹ By RICHARD E. MYERS, State climatologist for Nebraska, National Weather Service, U.S. Department of Commerce.

Rains early in spring are generally slow and steady and often last for one or two days. As spring advances, the amount of moisture received increases sharply. The amount of moisture that falls during showers and thunderstorms also increases, and by May most of the precipitation falls as showers and thunderstorms. Thundershowers in spring and early in summer are severe at times and may be accompanied by local downpours, hail, and damaging winds. About once each year, $1\frac{1}{2}$ inches of rain falls in one hour. Downpours that fall at a rate of more than 3 inches per hour and that last for about 15 minutes occur about once every two years. The hailstorms are generally local and of short duration. The pattern produced is extremely spotty and variable. Crops are totally lost in the center of intense hailstorms.

As seen in table 9, June receives more precipitation than any other month. Peak precipitation is reached about the middle of June followed by a marked decrease in shower activity until the low point in summer precipitation is reached during the third week of July.

Rainfall increases again by the end of July and holds through August and early into September before beginning a steady decline through fall and the first weeks of winter. Fall has many warm, bright, sunshiny days.

The frequency of high and low temperatures is also shown in table 9. The days having the extremely high and low temperatures are likely to occur in groups. For example, the last week in July is the warmest of the year, having daily high temperatures of about 94°F . In about one year in ten, however, the daily high temperature during that week averages 102° or higher. Late in January the low daily temperatures for a week average 14° . In one year of ten, however, the average falls to 0° or lower. The highest recorded temperature was 117° in 1936. The lowest was -29° in 1915.

The probabilities of receiving freezing temperatures before specified dates in fall or after specified dates in spring are shown in table 10.

Annual free-water evaporation from shallow lakes is about 45 inches. About 75 percent of this evaporation occurs during the period of May through October.

TABLE 9.—*Temperature and precipitation data*

[Data from Pawnee City, Nebraska]

Month	Temperature				Precipitation				
	Average daily maximum ¹	Average daily minimum ¹	Two years in 10 will have at least 4 days with—		Average monthly total ¹	One year in 10 will have—		Days having 1 inch or more snow cover ⁴	Average depth of snow on days having snow cover ⁴
			Maximum temperature equal to or higher than ²	Minimum temperature equal to or lower than ²		Equal to or less than ³	Equal to or more than ³		
	$^{\circ}\text{F}$	$^{\circ}\text{F}$	$^{\circ}\text{F}$	$^{\circ}\text{F}$	Inches	Inches	Inches		Inches
January.....	37	16	57	-7	0.9	0.1	1.7	12	4
February.....	43	20	62	0	1.1	.1	2.3	8	3
March.....	52	29	76	13	2.1	.3	3.4	5	5
April.....	67	41	83	26	2.7	1.0	5.2	(⁵)	2
May.....	77	52	90	36	4.2	1.5	8.0	0	0
June.....	85	62	99	49	6.0	1.4	8.6	0	0
July.....	91	66	104	54	3.6	.8	7.3	0	0
August.....	90	65	101	52	4.6	1.3	7.4	0	0
September.....	81	55	97	40	4.0	1.2	8.1	0	0
October.....	72	44	87	28	2.3	.4	4.4	(⁵)	1
November.....	54	31	72	15	1.1	.1	3.5	1	3
December.....	42	21	59	-1	1.0	.2	2.0	8	4
Year.....	66	42	⁶ 104	⁷ -14	33.5	22.6	41.2	35	4

¹ Period of record: 1939-68.² Period of record: 1903-63.³ Period of record: 1878-1968.⁴ Period of record: 1937-66.⁵ Less than 0.5 day.⁶ Average annual highest temperature.⁷ Average annual lowest temperature.

TABLE 10.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data from Pawnee City. All freeze data are based on temperatures in a standard U.S. Weather Bureau thermometer shelter at a height of approximately 5 feet above the ground and in a representative exposure. Lower temperatures exist at times nearer the ground and in local areas subject to extreme air drainage]

Probability	Dates for given probability and temperature				
	16° F	20° F	24° F	28° F	32° F
Spring:					
1 year in 10 later than-----	April 1	April 7	April 17	April 27	May 11
2 years in 10 later than-----	March 27	April 2	April 12	April 22	May 5
5 years in 10 later than-----	March 16	March 23	April 2	April 11	April 25
Fall:					
1 year in 10 earlier than-----	November 4	October 28	October 17	October 8	September 27
2 years in 10 earlier than-----	November 10	November 2	October 23	October 13	October 2
5 years in 10 earlier than-----	November 21	November 12	November 1	October 23	October 12

Water Supply

Good-quality water for domestic and livestock needs is obtained from shallow wells, 25 to 100 feet deep, developed in sand lenses in the glacial till, in sandy alluvium in the stream valleys, and in perched water tables on flat uplands. Throughout most of the county, the amount of water available from these wells is limited to 1 to 10 gallons per minute during continuous pumping. Since these shallow wells depend on water received from the seepage and percolation of precipitation, prolonged periods of drought further reduce their yield. In the southeastern part of the county, and in other areas where shale and limestone crop out or are near the surface, it is difficult to develop a water supply for domestic use. In these areas, however, the springs, seeps, and wells in valley deposits yield a little water for livestock.

Ground-water studies in Pawnee County, performed by the Conservation and Survey Division, University of Nebraska, in cooperation with the U.S. Geological Survey, provide information on the availability of ground water. These studies indicate that before the glaciers advanced across Nebraska, streams had cut channels into the bedrock. These buried valleys were later filled with glacial material. Where the buried valleys contain sand and gravel, wells capable of producing several hundred gallons per minute can be developed. These areas, however, are limited and are not as yet completely defined. Test drilling located a buried valley eight miles north of Pawnee City. A municipal well field was established in that valley. Additional test drilling may locate other similar areas.

Deep-well tests indicate possible water supply in Permian rocks in the southwestern part of the county. The mineral content of this ground water is believed to be about 2,000 parts per million of total dissolved solids, which is too high for domestic uses but usable for livestock needs.

Small stock-water ponds are easily developed and are widely used to supply water for livestock needs. No reservoirs have been developed for municipal water supplies. Streams, reservoirs, and stock-water

ponds are also used for recreation. Surface water storage is an important supplement to the limited supply of ground water in Pawnee County. Its use for livestock and recreational needs extends the limited supply of good-quality ground water for domestic uses.

Transport Facilities and Markets

Paved State Highways No. 50 and 99 cross the county from north to south, and State Highways No. 4 and 8 cross the county from east to west. Many of the farm-to-market roads have crushed-rock surfaces. The remaining roads are of earthen construction.

A railroad runs through the county, connecting the towns of Burchard, Pawnee City, and Table Rock.

Two private landing strips in the county accommodate small aircraft.

Pawnee City has a sales ring, where livestock are auctioned, and a commercial hog market. A local cooperative operates a collection point for livestock to be trucked to market. St. Joseph, Missouri, and Omaha, Nebraska, are the largest livestock markets in the area, and most livestock are trucked to these markets.

Farming

The U.S. Census of Agriculture indicates that in 1969 there were 698 farms in Pawnee County. The average size of the farms was 344 acres. The trend is towards fewer farms of larger size. The number of resident tenants and owners on farms is also decreasing. About 86 percent of the county is farmland.

The acreage of corn, wheat, alfalfa, and clover was less in 1969 than in 1964, and the acreage of grain sorghum and soybeans was higher. Only four farms reported sales of standing timber in 1969.

Nearly all crops are grown without irrigation. Only one farm was classified as an irrigated farm in 1969, and only 130 acres were irrigated during that year.

In 1969, 33,919 cattle and calves, 36,485 hogs and pigs, and 4,026 sheep and lambs were in the county. The number of chickens dropped from 71,622 in 1964 to only 24,876 in 1969.

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Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. In this survey the classes of available water capacity for a 60-inch profile, or to a limiting layer, are:

0 to 3 inches	-----	Very low
3 to 6 inches	-----	Low
6 to 9 inches	-----	Moderate
More than 9 inches	-----	High

Buried soil. A developed soil, once exposed but now overlain by more recently formed soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the bases of steep slopes.

Complex, soil. A mapping unit consisting of different kinds of soils that occur in such small individual areas or in such an intricate pattern that they cannot be shown separately on a publishable soil map.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Depth, soil. The total thickness of weathered soil material over mixed sand and gravel or bedrock. Unless otherwise noted, the classes of soil depth used in this survey are as follows: (1) *very shallow*, 0 to 10 inches; (2) *shallow*, 10 to 20 inches; (3) *moderately deep*, 20 to 40 inches, and (4) *deep*, greater than 40 inches.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low available water capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Green manure (agronomy). A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of

clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none*, *very slow*, *slow*, *medium*, *rapid*, and *very rapid*.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Lime. Chemically, lime is calcium oxide (CaO), but its meaning has been extended to include all limestone-derived materials applied to neutralize acid soil. Agricultural lime can be obtained as ground limestone, hydrated lime, or burned lime, with or without magnesium minerals. Basic slag, oyster-shells, and marl also contain calcium.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows; abundance—*few*, *common*, and *many*; size—*fine*, *medium*, and *coarse*; and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Nutrient, plant. Any element taken in by a plant, essential to its growth, and used by it in the production of food and tissue. Nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, zinc, and perhaps other elements obtained from the soil and carbon, hydrogen, and oxygen obtained largely from the air and water, are plant nutrients.

Organic matter. A general term for plant and animal material in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that have already passed through the stage of rapid decomposition.

Permeability, soil. The quality of a moist soil that enables water or air to move through it. In this survey permeability applies to that part of the soil below the Ap, or equivalent layer, and above a depth of 60 inches or above bedrock that occurs at a shallower depth. Where there is a change of two or more permeability classes within a short vertical distance, the classes and depths are stated. Classes of soil permeability, expressed in inches of water per hour, are as follows:

Less than 0.06	Very slow
0.06 to 0.2	Slow
0.2 to 0.6	Moderately slow
0.6 to 2.0	Moderate
2.0 to 6.0	Moderately rapid
6.0 to 20.0	Rapid
More than 20	Very rapid

Phase, soil. A subdivision of a soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil series, for exam-

ple, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects its management but not its behavior in the natural landscape.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Range condition. The state of health or productivity of both soil and forage in a given range, in terms of what productivity could or should be under normal climate and the best practical management. Condition classes generally recognized are—*excellent*, *good*, *fair*, and *poor*. The classification is based on the percentage of original, or climax, vegetation on the site, as compared to what ought to grow on it if management were good.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		pH
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline-alkali soil. A soil that contains a harmful concentration of salts and exchangeable sodium; or contains harmful salts and has a highly alkaline reaction; or contains harmful salts and exchangeable sodium and is strongly alkaline. The salts, exchangeable sodium, and alkaline reaction occur in the soil in such location that growth of most crop plants is less than normal.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Slickspots. Small areas in a field that are slick when wet because they contain excess exchangeable sodium or alkali.

Slope. The degree of deviation of a surface from the horizontal, usually expressed as a percentage or in degrees. In this survey, the slope classes are: (1) 0 to 1 percent, nearly level; (2) 1 to 3 percent, very gently sloping; (3) 3 to 7 percent, gently sloping; (4) 5 to 9 percent, moderately sloping; (5) 9 to 12 percent, strongly sloping; (6) 12 to 17 percent, moderately steep; (7) 17 to 30 percent, steep; (8) 30 to 60 percent, very steep.

Soil. A natural, three-dimensional body of the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Stratified. Composed of, or arranged in, strata, or layers, such as stratified alluvium. The term is confined to geological material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from ad-

joining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grained* (each grain by itself, as in dune sand) or *massive* (the particles) adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface layer. A term used in nontechnical soil descriptions for one or more layers above the subsoil. Includes A horizon and part of B horizon; has no depth limit.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Wilting point (or permanent wilting point). The moisture content of soil, on an oven-dry basis, at which plants (specifically sunflower) wilt so much that they do not recover when placed in a dark, humid atmosphere.

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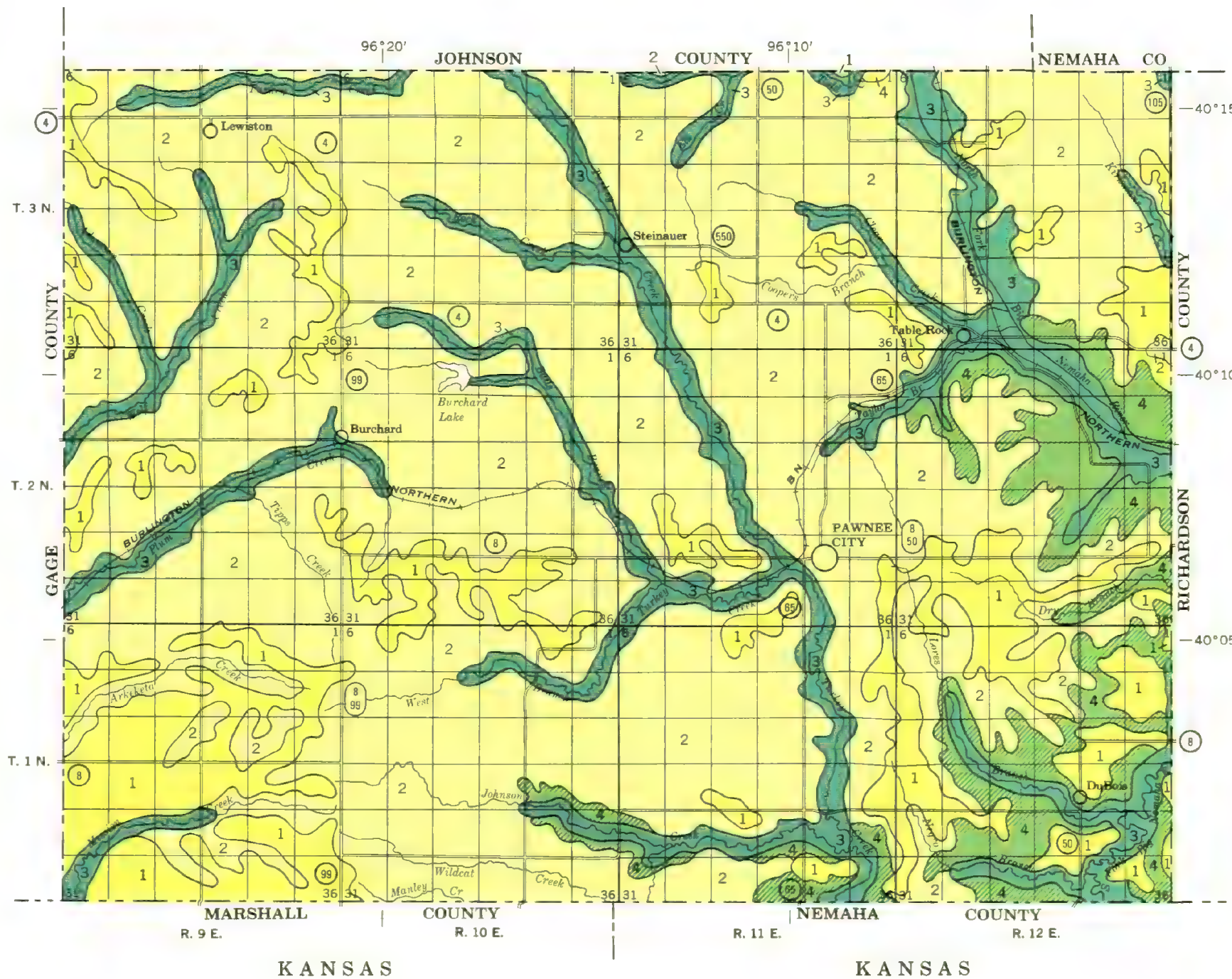
- (1) mail: U.S. Department of Agriculture
Office of the Assistant Secretary for Civil Rights
1400 Independence Avenue, SW
Washington, D.C. 20250-9410;
- (2) fax: (202) 690-7442; or
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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
UNIVERSITY OF NEBRASKA, CONSERVATION AND SURVEY DIVISION
GENERAL SOIL MAP
PAWNEE COUNTY, NEBRASKA

Scale 1:190,080
1 0 1 2 3 4 Miles



SOIL ASSOCIATIONS*

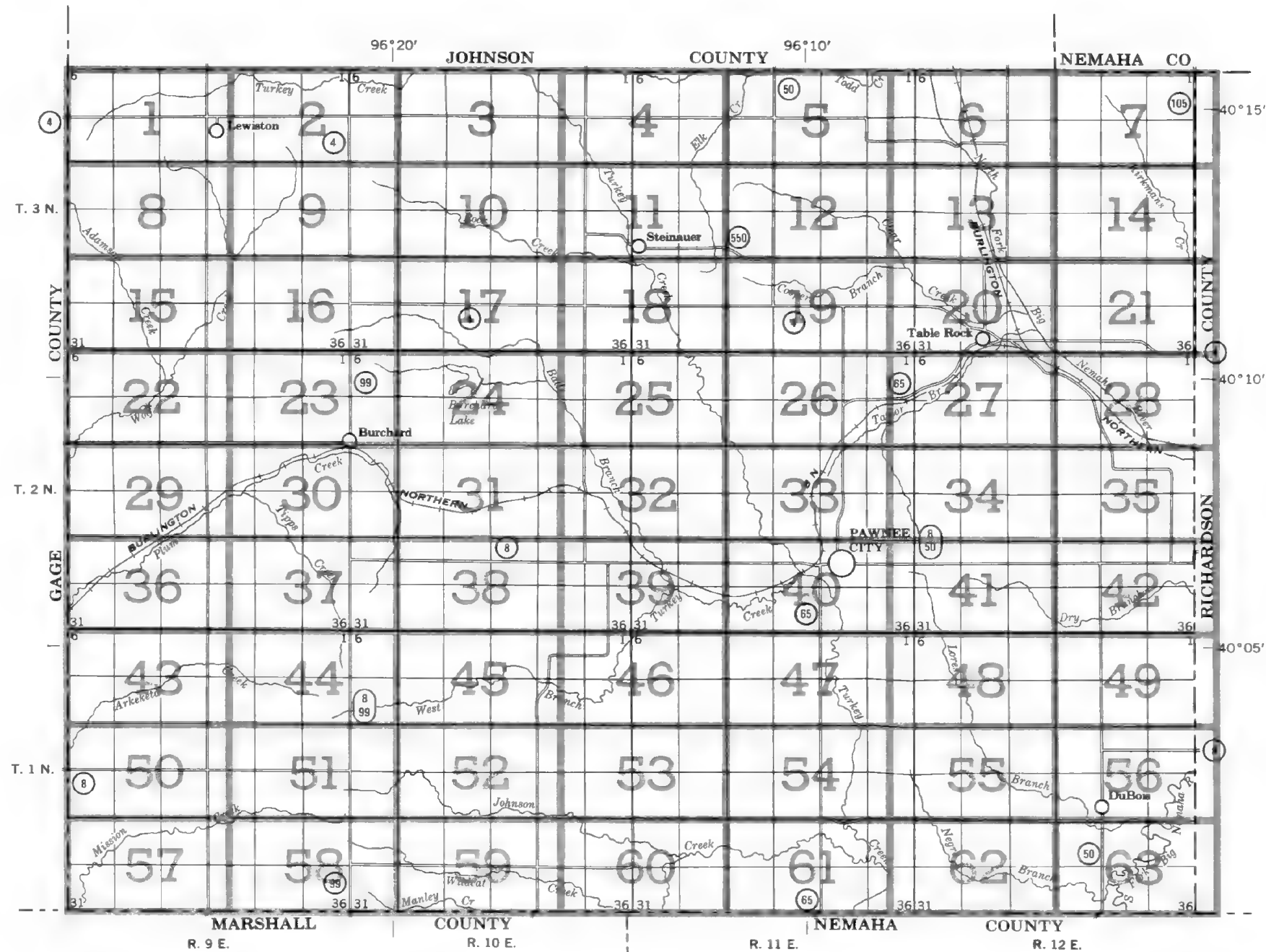
- 1 Wymore association: Deep, nearly level to gently sloping, silty to clayey soils on loess-capped uplands
- 2 Pawnee-Mayberry-Burchard association: Deep, nearly level to moderately steep, loamy and clayey soils on glacial uplands
- 3 Kennebec-Judson-Wabash association: Deep, nearly level to gently sloping, silty and clayey soils on bottom lands
- 4 Benfield-Kipson-Sogn association: Moderately deep and shallow, gently sloping to very steep, silty and clayey soils on shale and limestone uplands

* Texture refers to the surface layer of the major soils in each soil association.

Compiled 1974

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.

SECTIONALIZED TOWNSHIP						
6	5	4	3	2	1	
7	8	9	10	11	12	
18	17	16	15	14	13	
19	20	21	22	23	24	
30	29	28	27	26	25	
31	32	33	34	35	36	



INDEX TO MAP SHEETS
PAWNEE COUNTY, NEBRASKA



SECTIONALIZED TOWNSHIP					
6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

SOIL LEGEND

The first letter, always a capital, is the initial letter of the soil name. If slope is given in the soil name and is more than one percent, the last capital letter, B, C, D, E, or F, in a symbol shows the dominant slope class. A final number, 2 or 3, in the symbol shows that the soil is eroded or severely eroded.

SYMBOL	NAME
BbC2	Benfield silty clay loam, 3 to 9 percent slopes, eroded
BcC3	Benfield soils, 3 to 9 percent slopes, severely eroded
BdD	Burchard clay loam, 5 to 12 percent slopes
BdE	Burchard clay loam, 12 to 17 percent slopes
Bu	Butler silt loam
Ck	Colo and Kennebec soils, occasionally flooded
Cr	Crete silt loam, terrace
JuC	Judson silt loam, 1 to 5 percent slopes
Ke	Kennebec silt loam
KFE	Kipson-Benfield silty clay loams, 5 to 17 percent slopes
KsF	Kipson-Sogn complex
McD	Malcolm complex, 5 to 12 percent slopes
McF	Malcolm complex, 12 to 25 percent slopes
MdC	Mayberry loam, 3 to 9 percent slopes
MeC2	Mayberry clay loam, 3 to 9 percent slopes, eroded
MFC3	Mayberry soils, 3 to 9 percent slopes, severely eroded
MrC	Morrill loam, 3 to 5 percent slopes
MrD	Morrill loam, 5 to 12 percent slopes
MrE	Morrill loam, 12 to 17 percent slopes
MsD3	Morrill soils, 5 to 12 percent slopes, severely eroded
MsE3	Morrill soils, 12 to 17 percent slopes, severely eroded
PaB	Pawnee loam, 0 to 3 percent slopes
PaC	Pawnee loam, 3 to 9 percent slopes
PnC2	Pawnee clay loam, 3 to 9 percent slopes, eroded
PsC3	Pawnee soils, 3 to 9 percent slopes, severely eroded
PwD3	Pawnee and Mayberry soils, 9 to 12 percent slopes, severely eroded
Rg	Rough broken and gullied land
SbD	Shelby clay loam, 5 to 12 percent slopes
SkE	Shelby and Burchard clay loams, 12 to 17 percent slopes
StD	Steinauer clay loam, 5 to 12 percent slopes
StF	Steinauer clay loam, 12 to 21 percent slopes
Sy	Silty alluvial land
Wa	Wabash silty clay loam
Ws	Wabash silty clay
Wx	Wet alluvial land
WyB	Wymore silty clay loam, 0 to 3 percent slopes
WyC	Wymore silty clay loam, 3 to 7 percent slopes
WyC2	Wymore silty clay loam, 3 to 7 percent slopes, eroded
WzC3	Wymore soils, 3 to 7 percent slopes, severely eroded

WORKS AND STRUCTURES

Highways and roads	
Divided	
Good motor	
Poor motor	
Trail	
Highway markers	
National Interstate	
U. S.	
State or county	
Railroads	
Single track	
Multiple track	
Abandoned	
Bridges and crossings	
Road	
Trail	
Railroad	
Ferry	
Ford	
Grade	
R. R. over	
R. R. under	
Buildings	
School	
Church	
Mine and quarry	
Gravel pit	
Power line	
Pipeline	
Cemetery	
Dams	
Levee	
Tanks	
Well, oil or gas	
Forest fire or lookout station ...	
Windmill	
Located object	

CONVENTIONAL SIGNS

BOUNDARIES

National or state	
County	
Minor civil division	
Reservation	
Land grant	
Small park, cemetery, airport ...	
Land survey division corners ...	

DRAINAGE

Streams, double-line	
Perennial	
Intermittent	
Streams, single-line	
Perennial	
Intermittent	
Crossable with tillage implements	
Not crossable with tillage implements	
Unclassified	
Canals and ditches	
Lakes and ponds	
Perennial	
Intermittent	
Spring	
Marsh or swamp	
Wet spot	
Drainage end or alluvial fan ...	

RELIEF

Escarments	
Bedrock	
Other	
Short steep slope	
Prominent peak	
Depressions	
Crossable with tillage implements	
Not crossable with tillage implements	
Contains water most of the time	

SOIL SURVEY DATA

Soil boundary	
and symbol	
Gravel	
Stoniness	
Stony	
Very stony	
Rock outcrops	
Chert fragments	
Clay spot	
Sand spot	
Gumbo or scabby spot	
Made land	
Severely eroded spot	
Blowout, wind erosion	
Gully	
Saline spot	

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. Information about the use and management of each soil is given in the description of the capability unit, range site, or windbreak suitability group to which it is assigned. Other information is given in tables as follows:

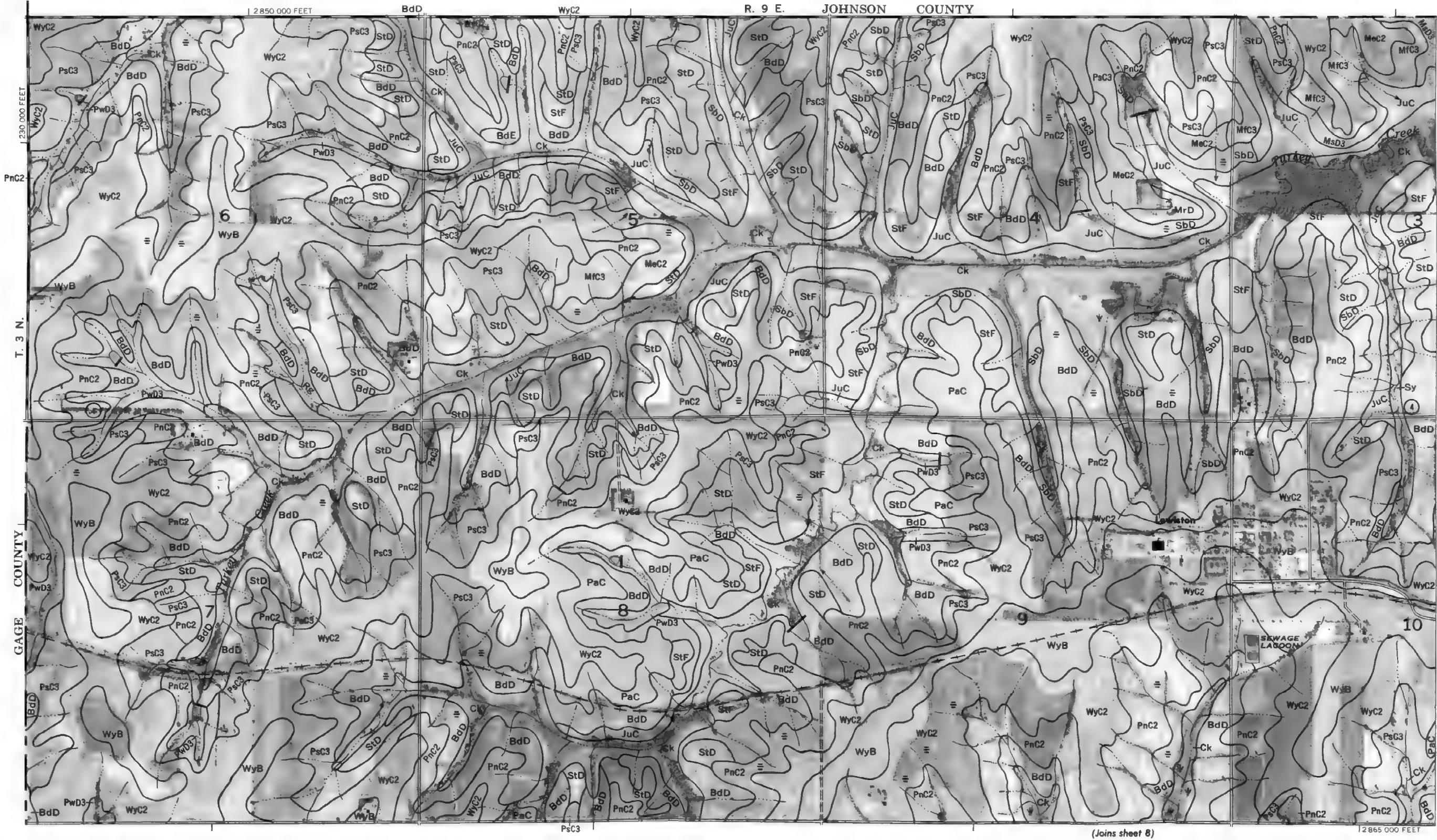
Acreage and extent, table 1, page 9.
Predicted yields, table 2, page 41.

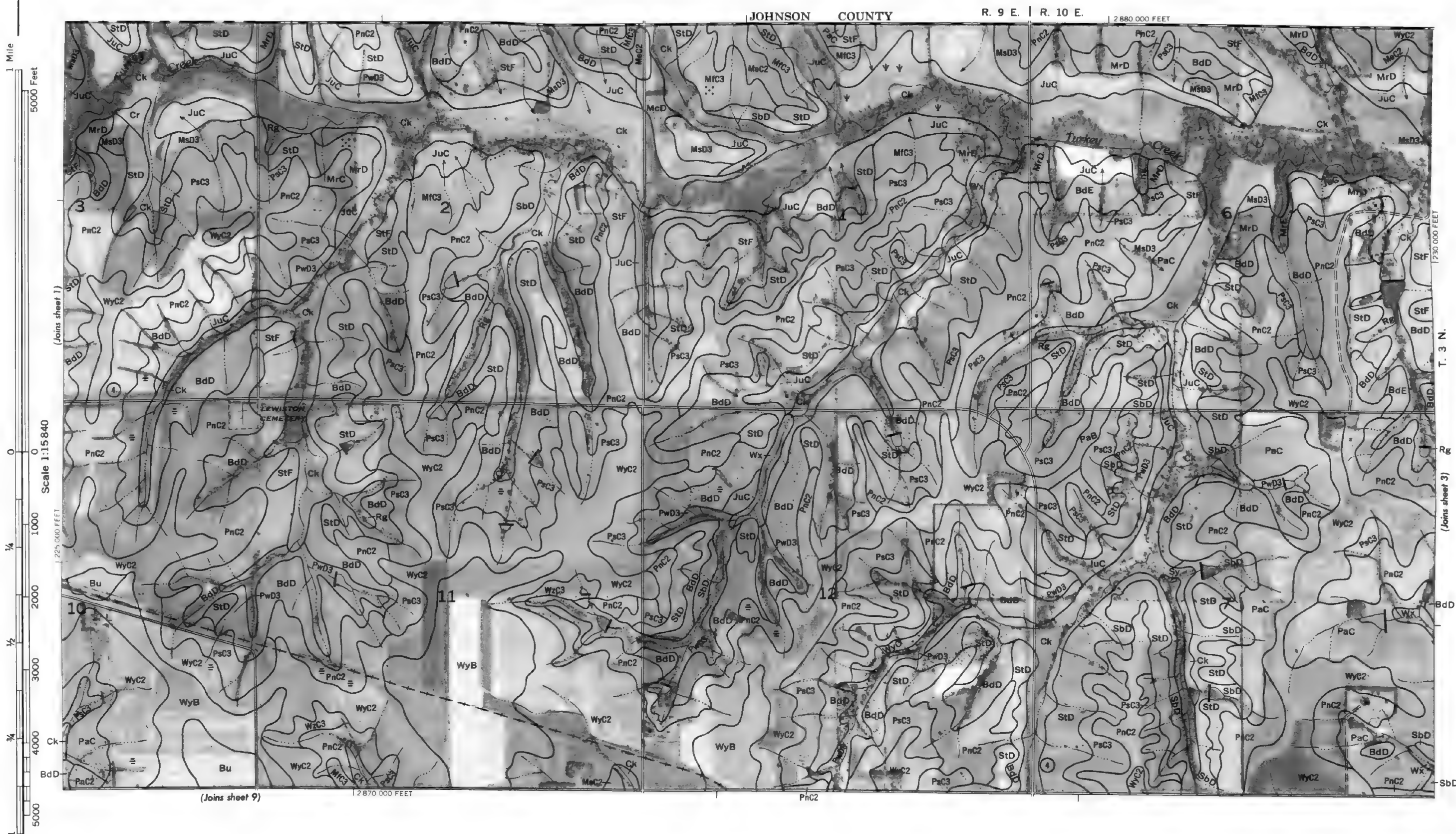
Engineering uses of the soils, table 5, page 52,
table 6, page 54, and table 7, page 58.

Map symbol	Mapping unit	Page	Capability unit	Range site	Windbreak suitability group
			Symbol	Page	Name
BbC2	Benfield silty clay loam, 3 to 9 percent slopes, eroded-----	9	IIIe-2	33	Clayey
BcC3	Benfield soils, 3 to 9 percent slopes, severely eroded-----	9	IVe-4	35	Dense Clay
BdD	Burchard clay loam, 5 to 12 percent slopes----	11	IIIe-1	33	Silty
BdE	Burchard clay loam, 12 to 17 percent slopes----	11	IVe-1	35	Silty
Bu	Butler silt loam-----	11	IIw-2	32	Clayey
Ck	Colo and Kennebec soils, occasionally flooded-- Colo soil-----	12	IIw-3	33	-----
	Kennebec soil-----	--	-----	--	Silty Overflow
Cr	Crete silt loam, terrace-----	13	IIIs-2	32	Silty Lowland
JuC	Judson silt loam, 1 to 5 percent slopes-----	13	IIe-1	31	Clayey
Ke	Kennebec silt loam-----	14	I-1	31	Silty Lowland
KfE	Kipson-Benfield silty clay loams, 5 to 17 percent slopes-----	15	VIIs-4	38	-----
	Kipson soil-----	--	-----	--	Shallow Limy
	Benfield soil-----	--	-----	--	Clayey
KsF	Kipson-Sogn complex-----	16	VIIIs-4	39	Shallow Limy
McD	Malcolm complex, 5 to 12 percent slopes-----	17	IVe-1	35	Silty
McF	Malcolm complex, 12 to 25 percent slopes-----	17	VIe-1	36	Silty
MdC	Mayberry loam, 3 to 9 percent slopes-----	18	IIIe-2	33	Clayey
MeC2	Mayberry clay loam, 3 to 9 percent slopes, eroded-----	18	IIIe-2	33	Clayey
MfC3	Mayberry soils, 3 to 9 percent slopes, severely eroded-----	18	IVe-4	35	Dense Clay
MrC	Morrill loam, 3 to 5 percent slopes-----	19	IIe-1	31	Silty
MrD	Morrill loam, 5 to 12 percent slopes-----	20	IIIe-1	33	Silty
MrE	Morrill loam, 12 to 17 percent slopes-----	20	IVe-1	35	Silty

Map symbol	Mapping unit	Page	Capability unit	Range site	Windbreak suitability group
			Symbol	Page	Name
MsD3	Morrill soils, 5 to 12 percent slopes, severely eroded-----	20	IVe-8	35	Silty
MsE3	Morrill soils, 12 to 17 percent slopes, severely eroded-----	20	VIe-8	37	Silty
PaB	Pawnee loam, 0 to 3 percent slopes-----	21	IIIs-2	32	Clayey
PaC	Pawnee loam, 3 to 9 percent slopes-----	22	IIIe-2	33	Clayey
PnC2	Pawnee clay loam, 3 to 9 percent slopes, eroded-----	22	IIIe-2	33	Clayey
PsC3	Pawnee soils, 3 to 9 percent slopes, severely eroded-----	22	IVe-4	35	Dense Clay
PwD3	Pawnee and Mayberry soils, 9 to 12 percent slopes, severely eroded-----	22	VIe-4	36	Dense Clay
Rg	Rough broken and gullied land-----	22	VIIe-7	39	Silty
SbD	Shelby clay loam, 5 to 12 percent slopes-----	23	IIIe-1	33	Silty
SkE	Shelby and Burchard clay loams, 12 to 17 percent slopes-----	24	IVe-1	35	Silty
StD	Steinauer clay loam, 5 to 12 percent slopes----	26	IVe-9	36	Limy Upland
StF	Steinauer clay loam, 12 to 21 percent slopes----	26	VIe-9	38	Limy Upland
Sy	Silty alluvial land-----	24	VIw-7	39	Silty Overflow
Wa	Wabash silty clay loam-----	27	IIIw-2	34	Clayey Overflow
Ws	Wabash silty clay-----	27	IIIw-1	34	Clayey Overflow
Wx	Wet alluvial land-----	27	Vw-7	36	Wet land
WyB	Wymore silty clay loam, 0 to 3 percent slopes--	28	IIIs-2	32	Clayey
WyC	Wymore silty clay loam, 3 to 7 percent slopes--	28	IIIe-2	33	Clayey
WyC2	Wymore silty clay loam, 3 to 7 percent slopes, eroded-----	28	IIIe-2	33	Clayey
WzC3	Wymore soils, 3 to 7 percent slopes, severely eroded-----	29	IVe-4	35	Dense Clay

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid lines are approximate and based on the Nebraska coordinate system, south zone. Land division corners are approximately positioned on this map.



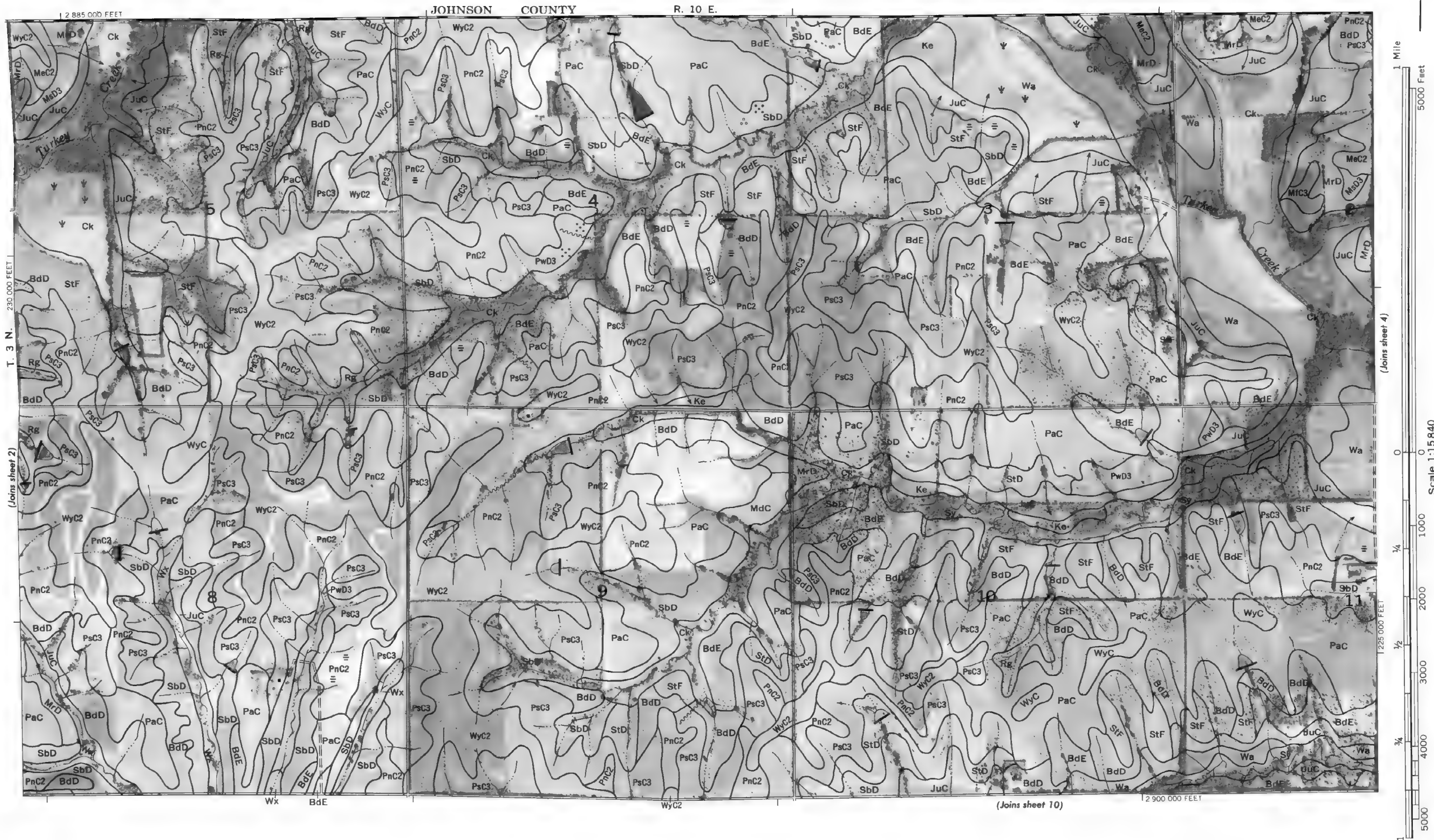


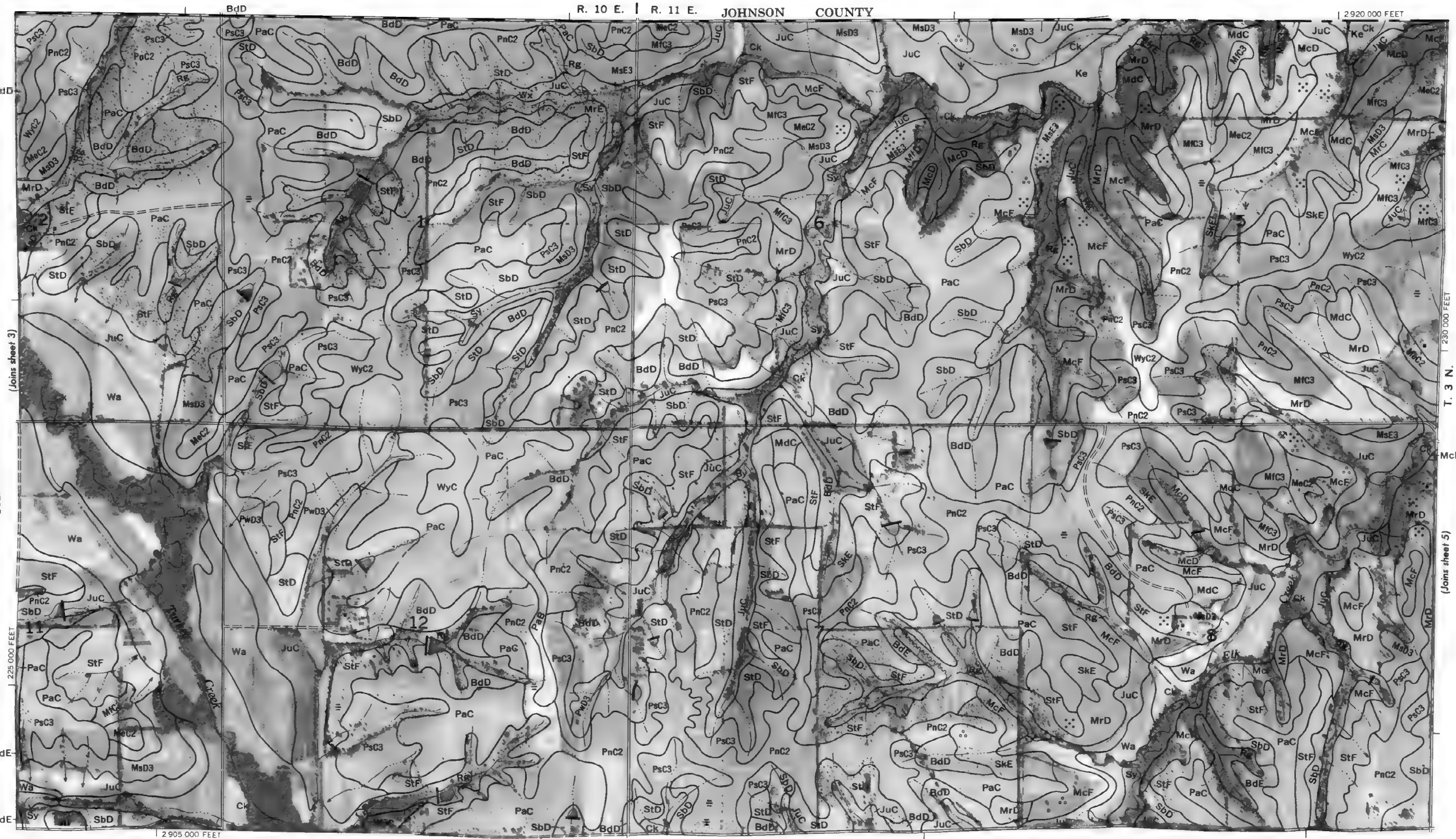
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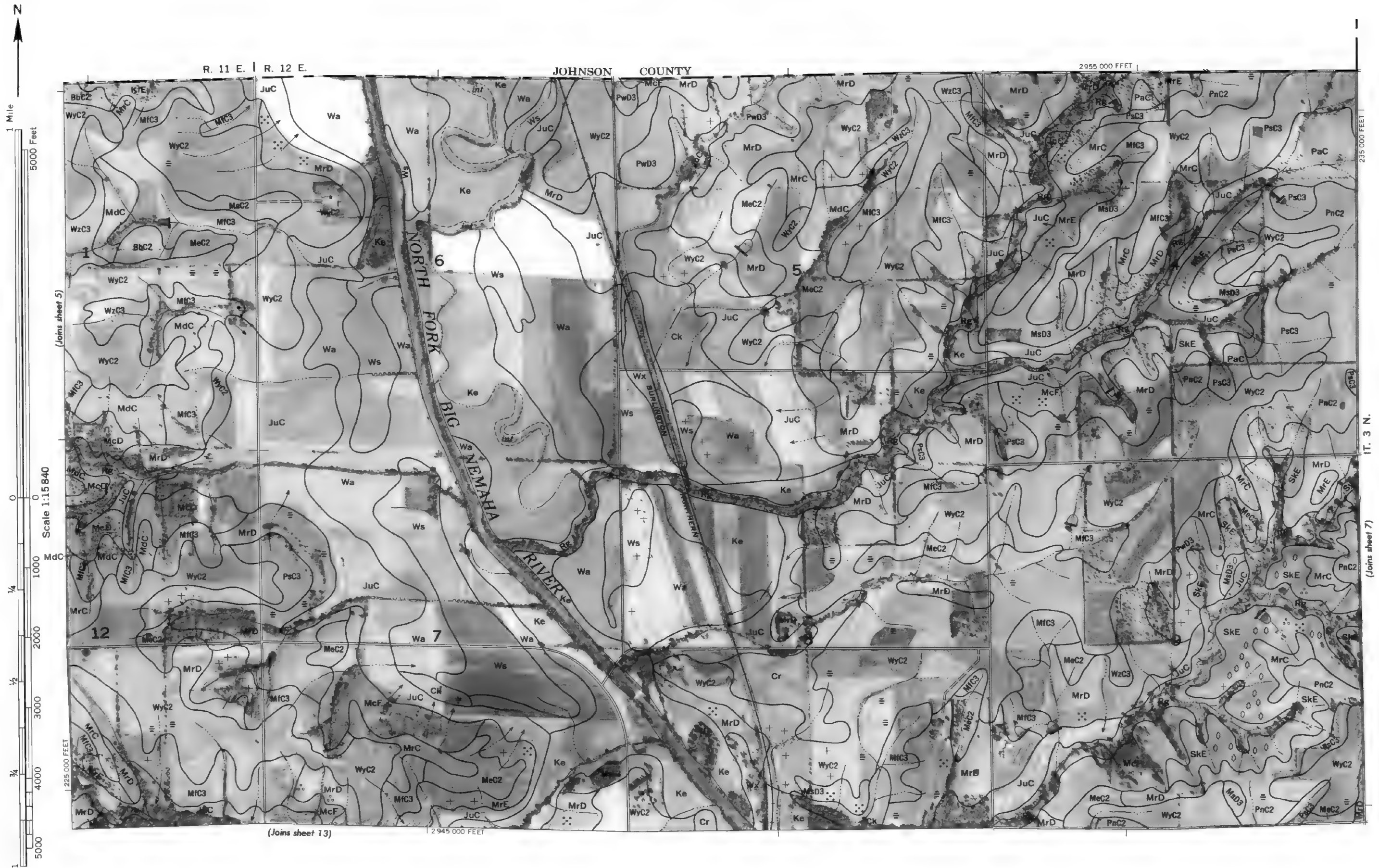




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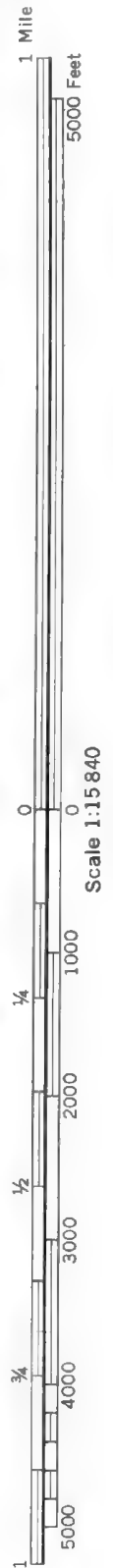
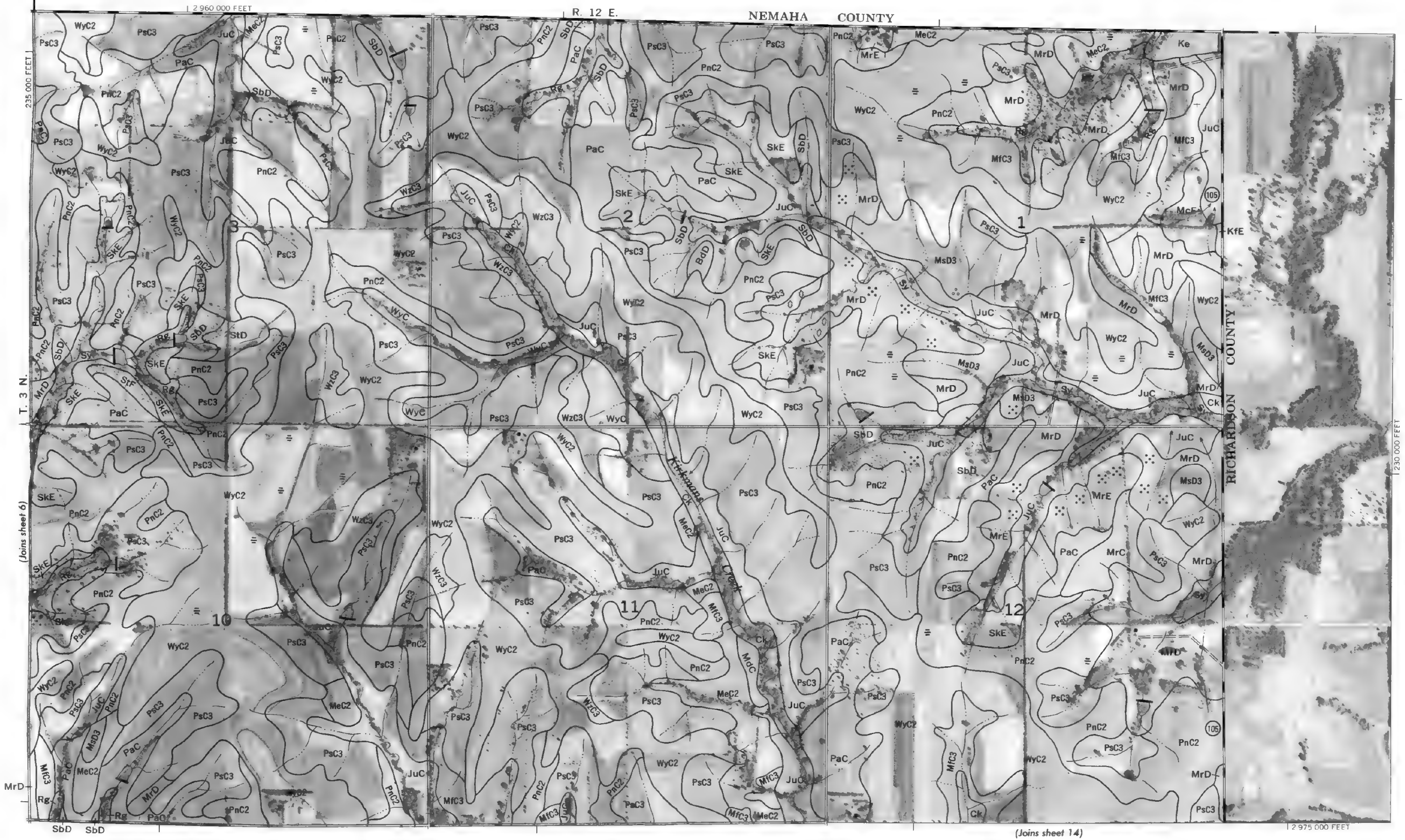


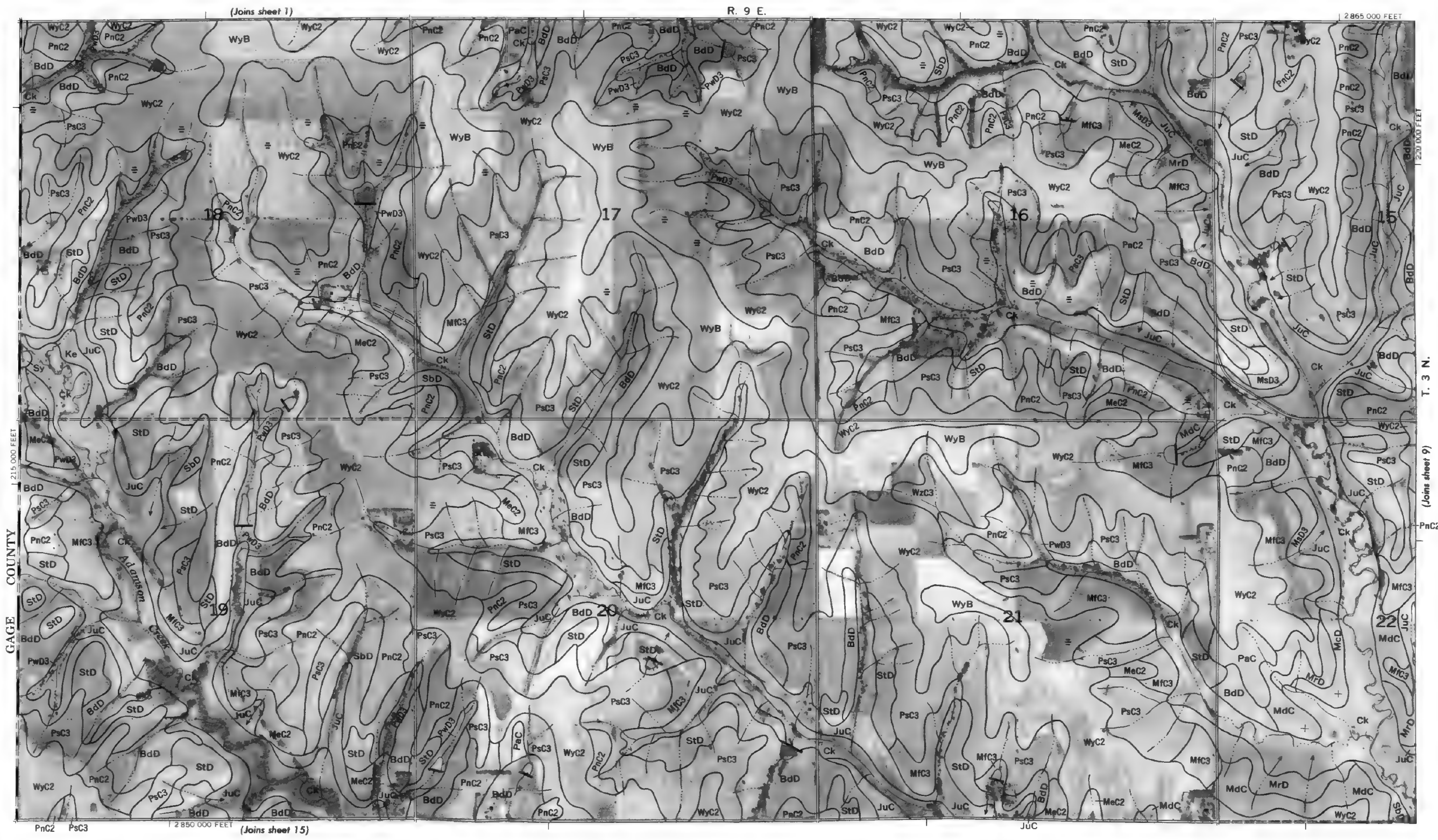
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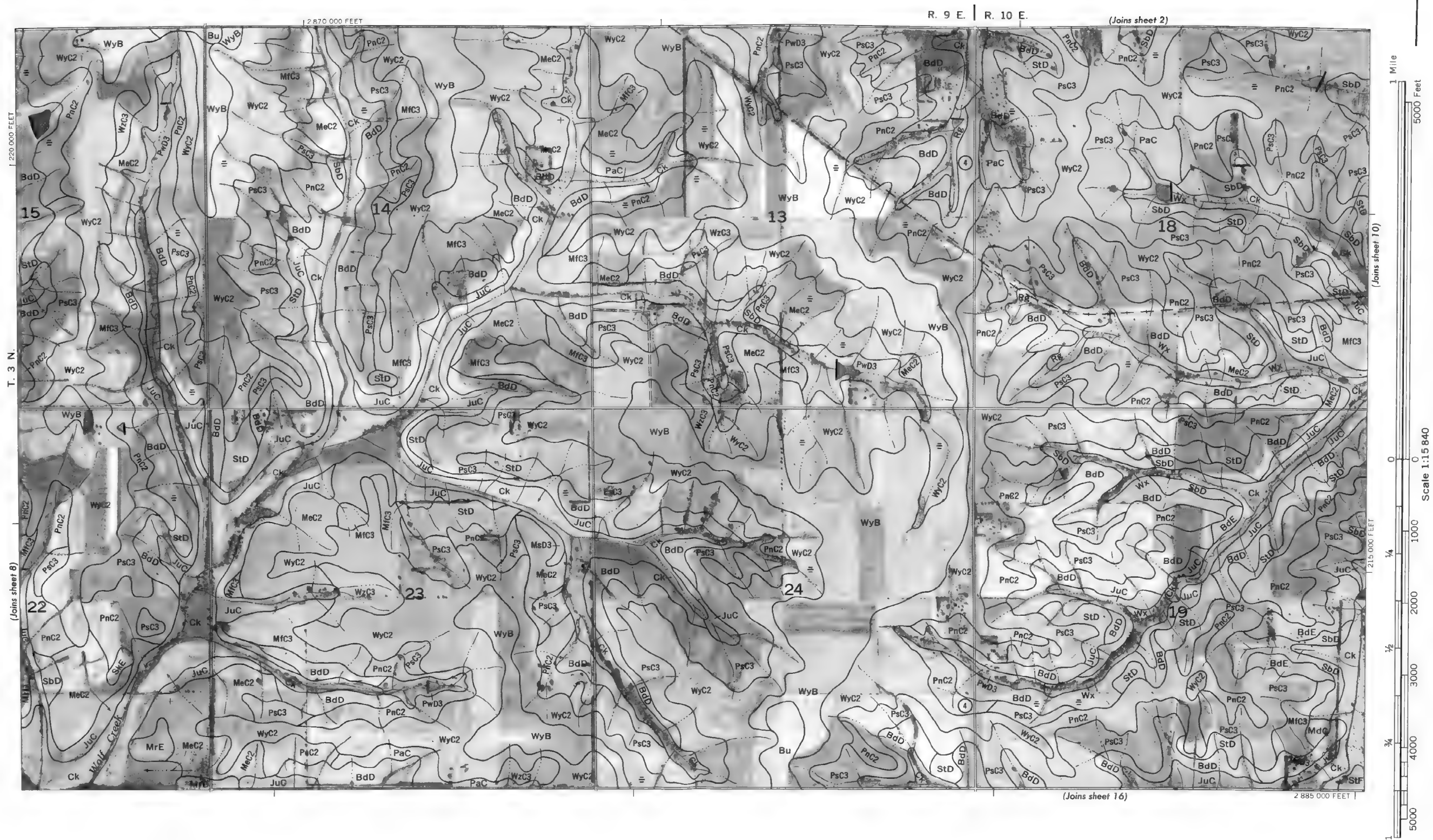


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PAWNEE COUNTY, NEBRASKA NO. 8

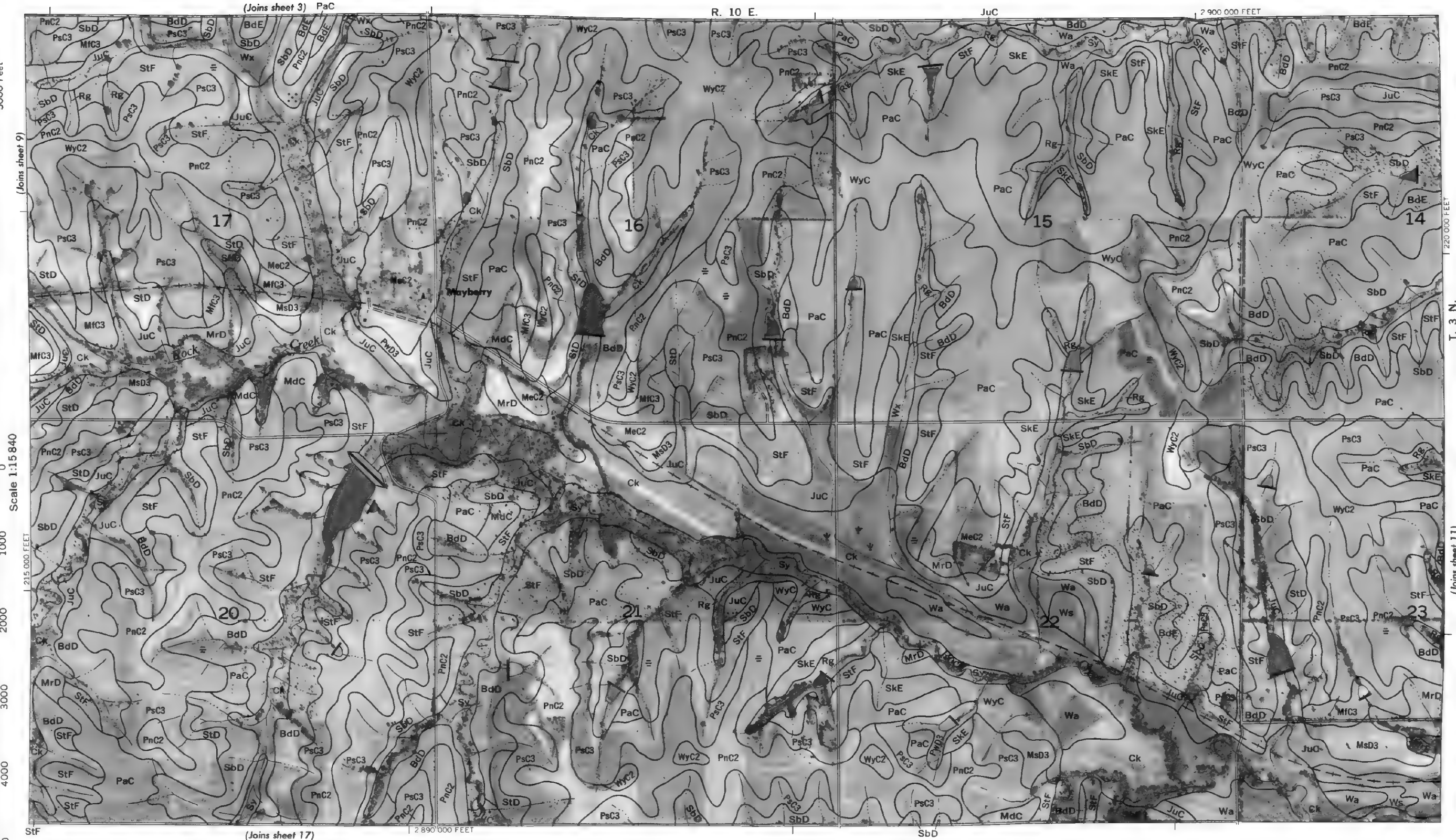
PAWNEE COUNTY, NEBRASKA NO. 9

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1 Mile
5000 Feet
0
1000
2000
3000
4000
5000

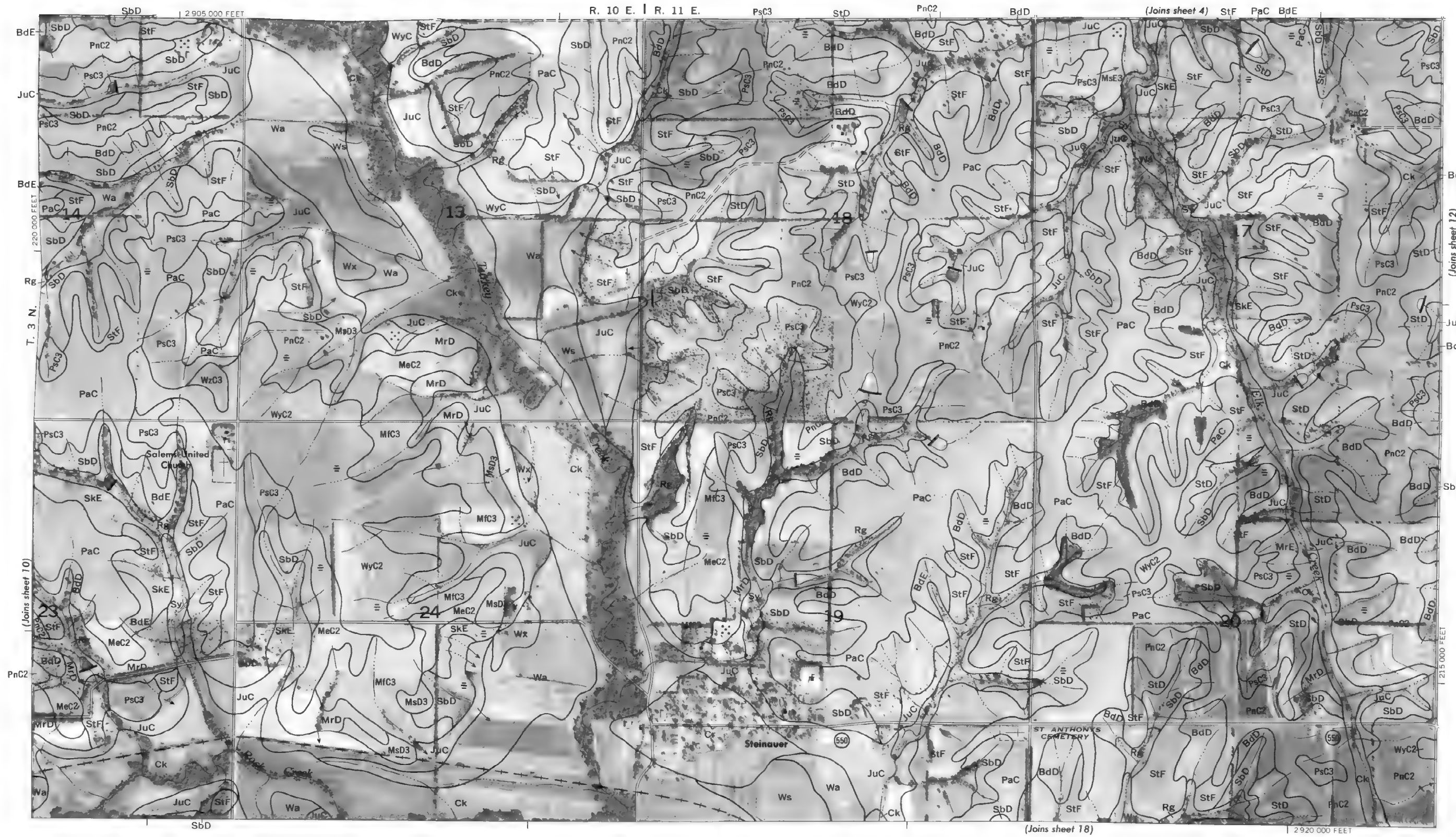


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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
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PAWNEE COUNTY, NEBRASKA NO. 10

Graphic scale bar showing distances in miles and feet. The top scale is in miles (0 to 1) and the bottom scale is in feet (0 to 5000). The scale is labeled "Scale 1:15,840".

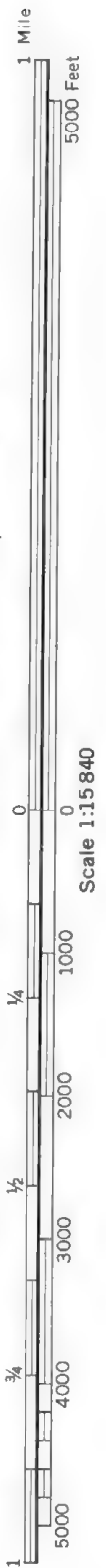
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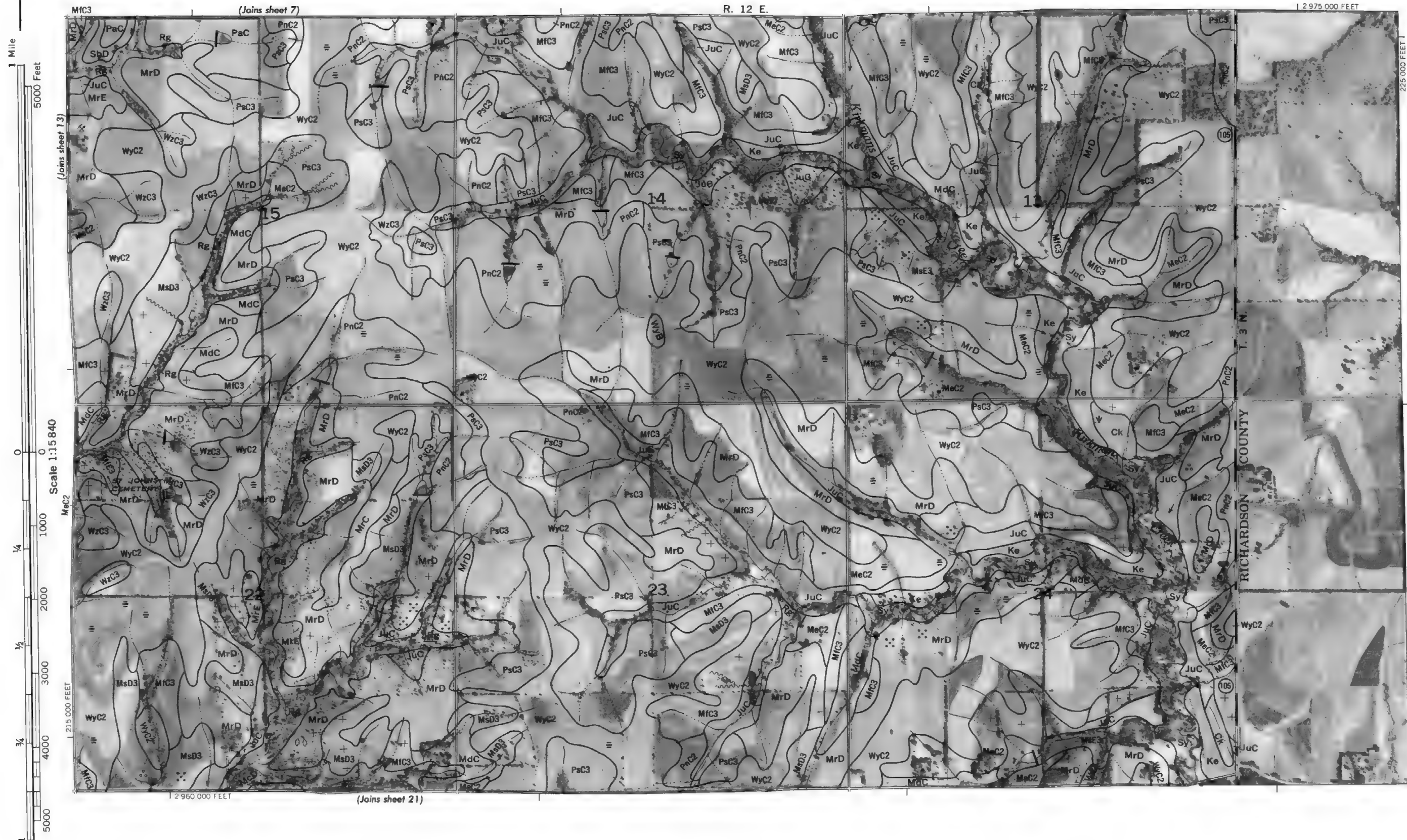


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Land division corners are approximately positioned on this map.

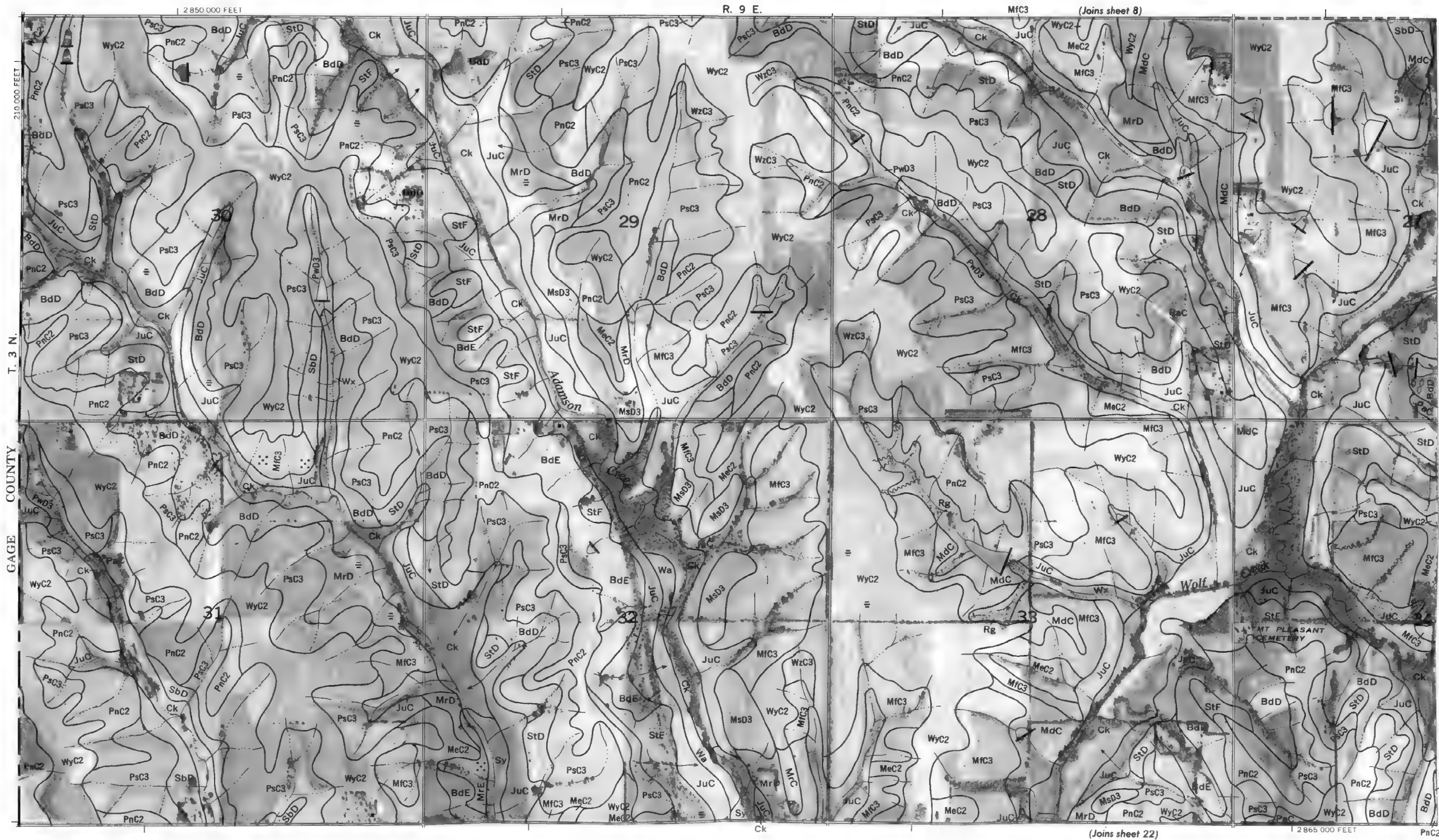
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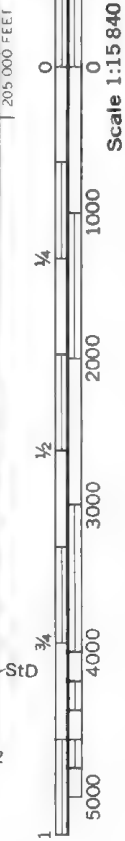
PAWNEE COUNTY, NEBRASKA NO. 14

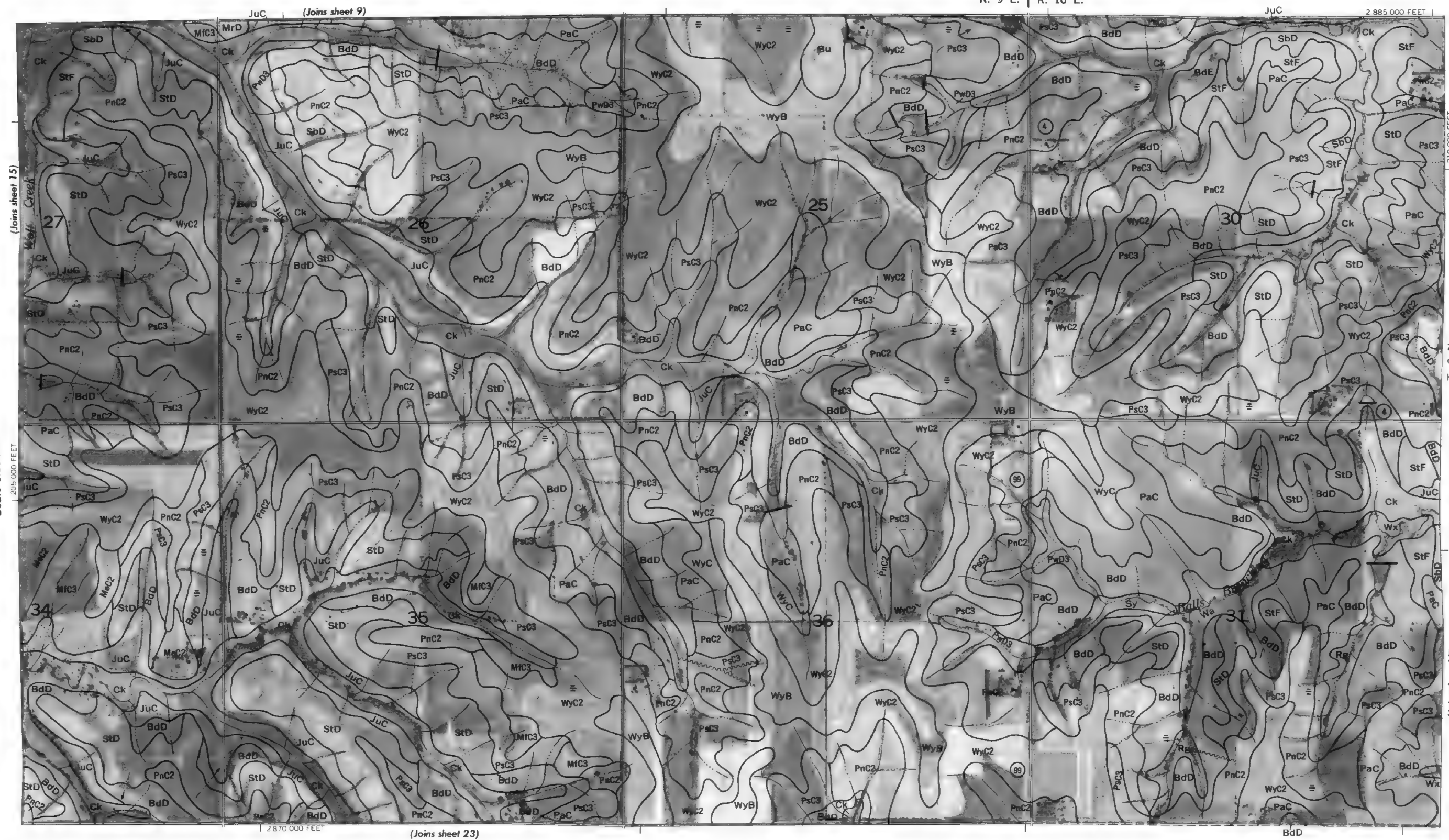


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(Joins sheet 16)





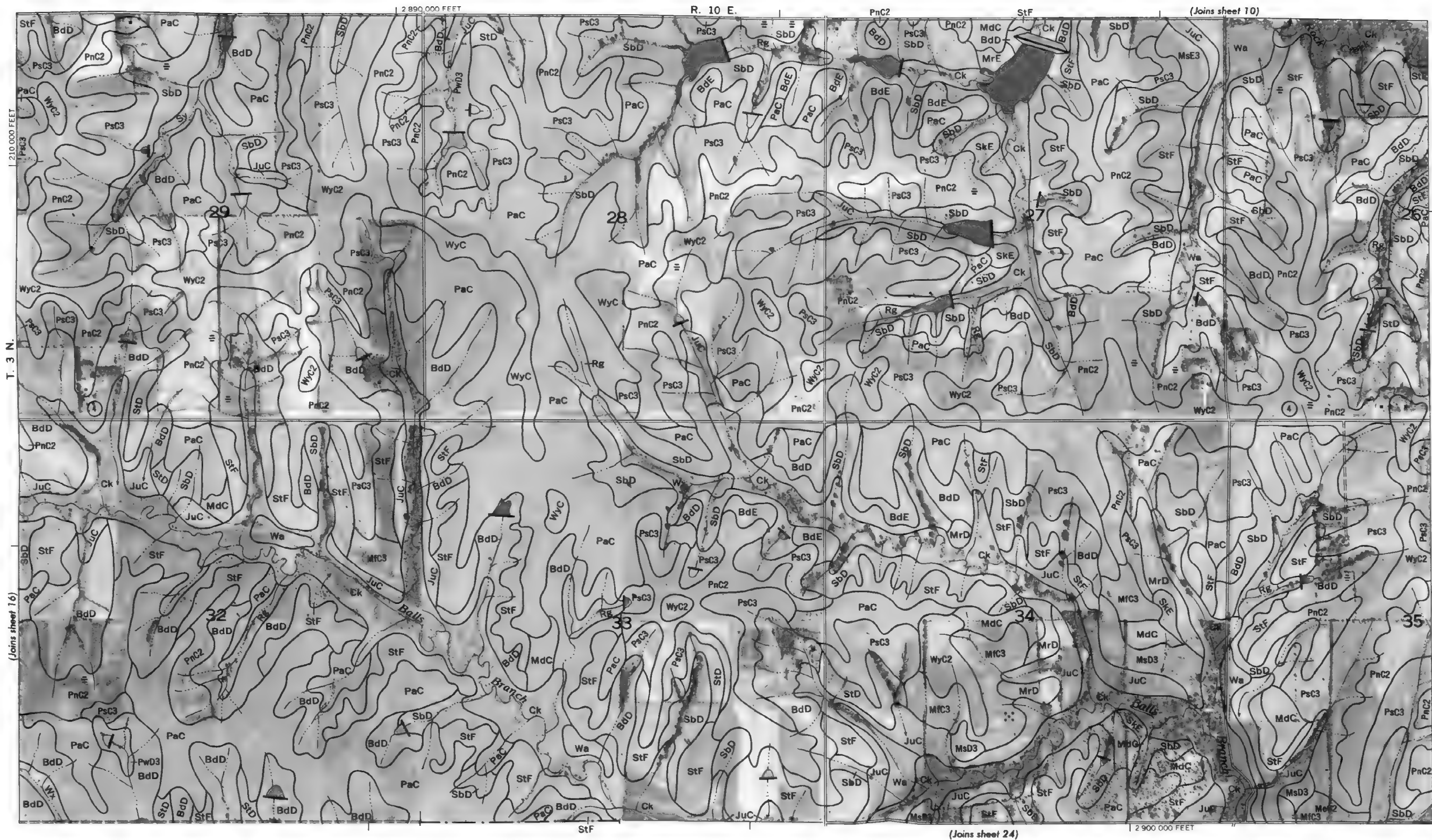
Land division corners are approximately positioned on this map.

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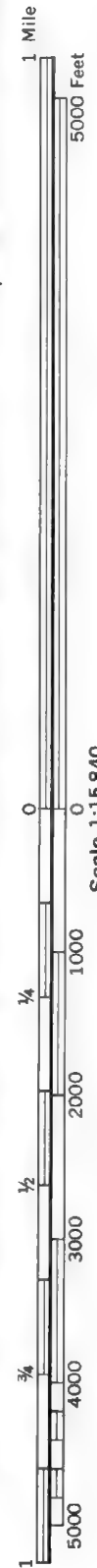
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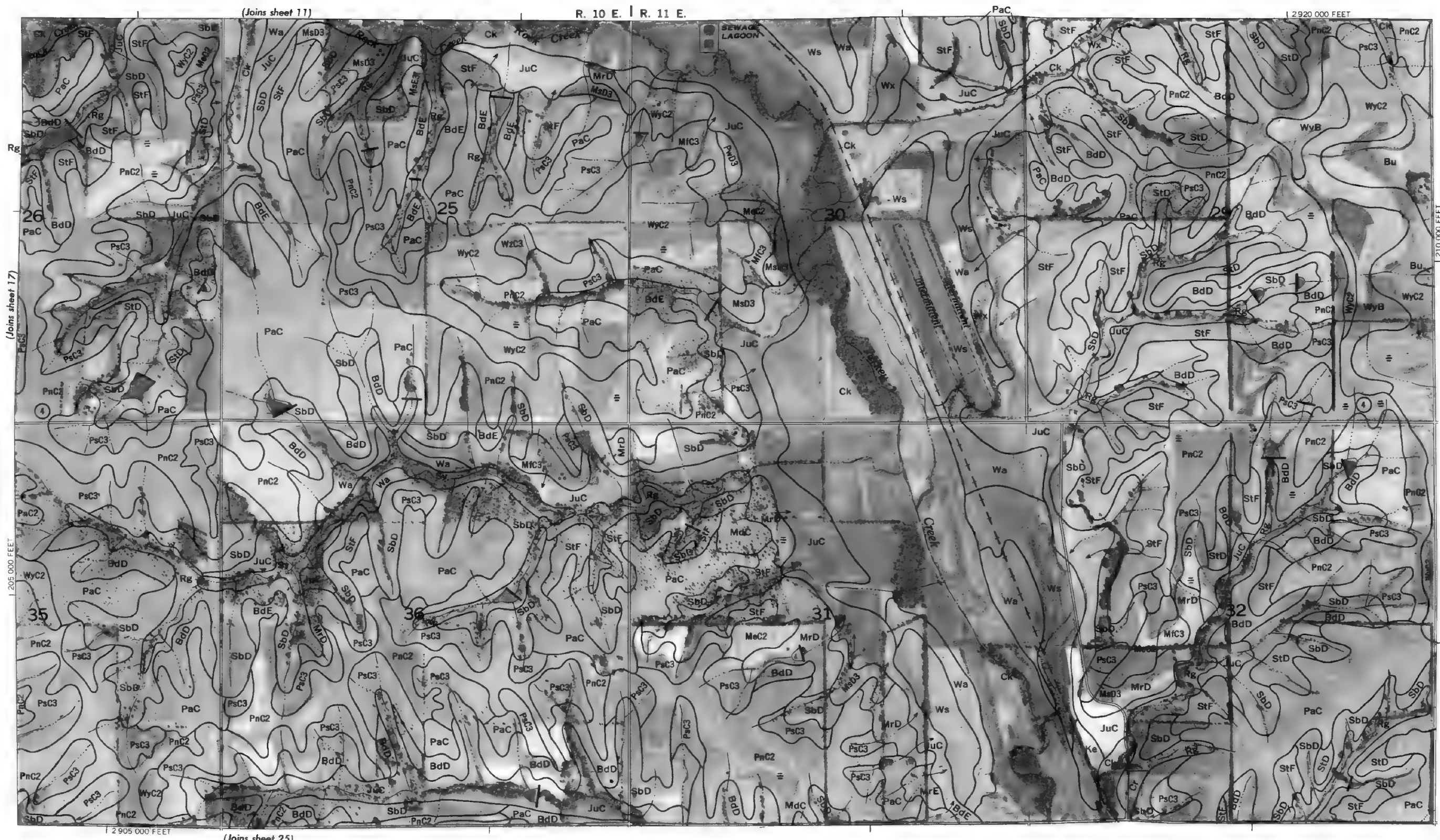
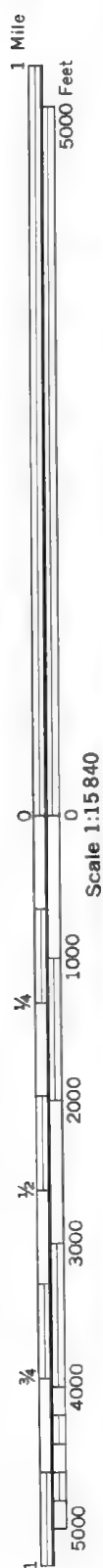
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Land division corners are approximately positioned on this map.



(Joins sheet 18)

(Joins sheet 24)





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Land division corners are approximately positioned on this map.

PAWNEE COUNTY, NEBRASKA NO. 18

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Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone
Land division corners are approximately positioned on this map



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(Joins sheet 13)

1 2955 000 FEET

T. 3 N. 210 000 FEET

Volume 4, 211

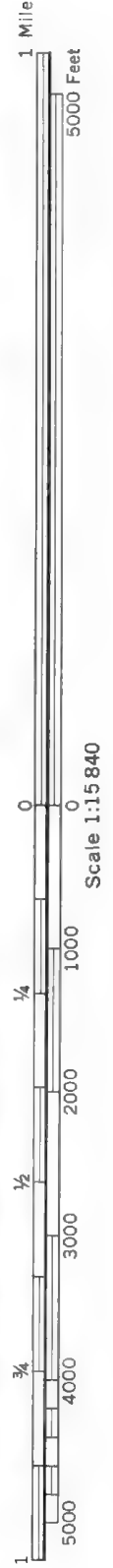
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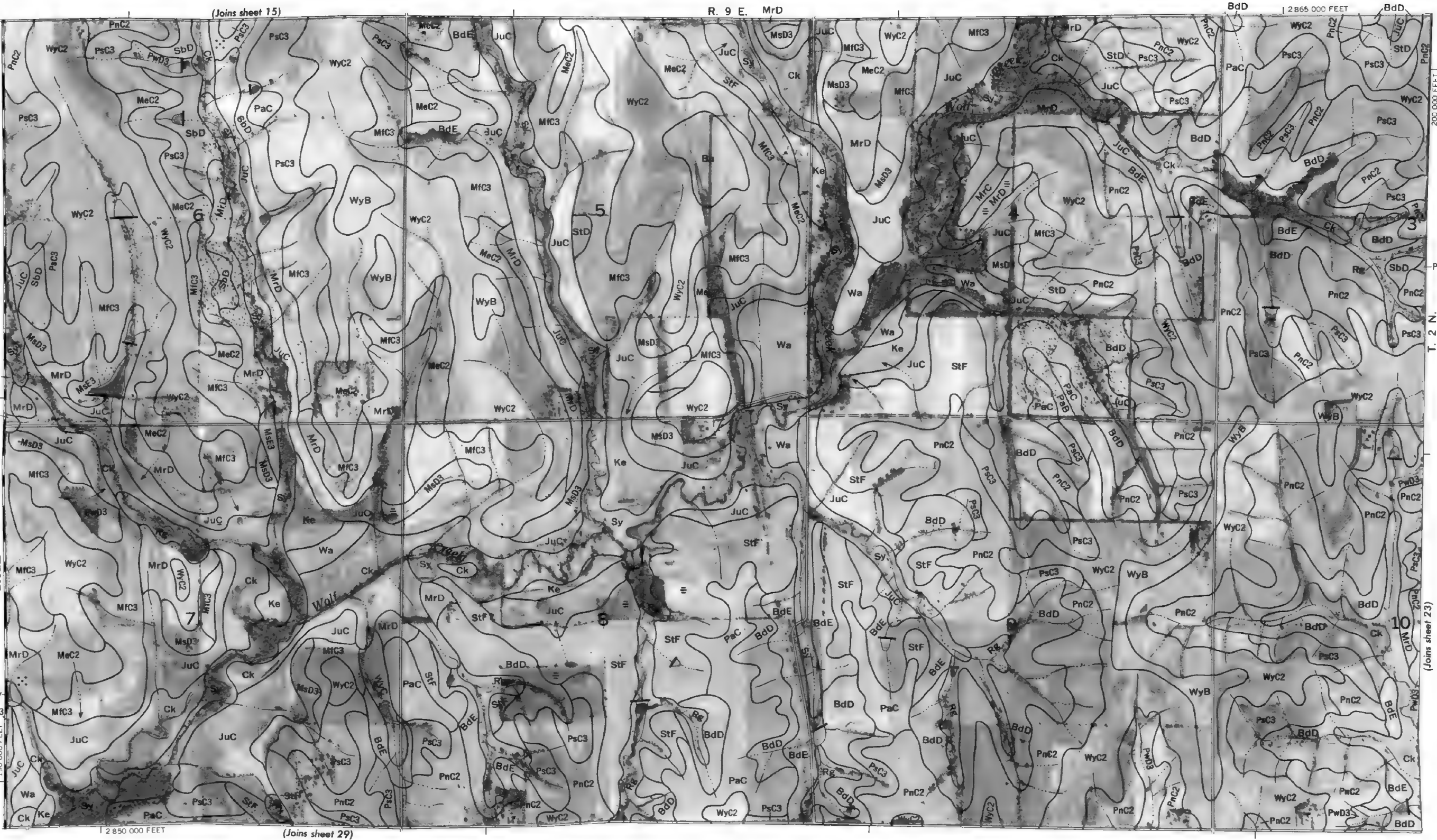
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This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division

PAWNEE COUNTY, NEBRASKA NO. 20

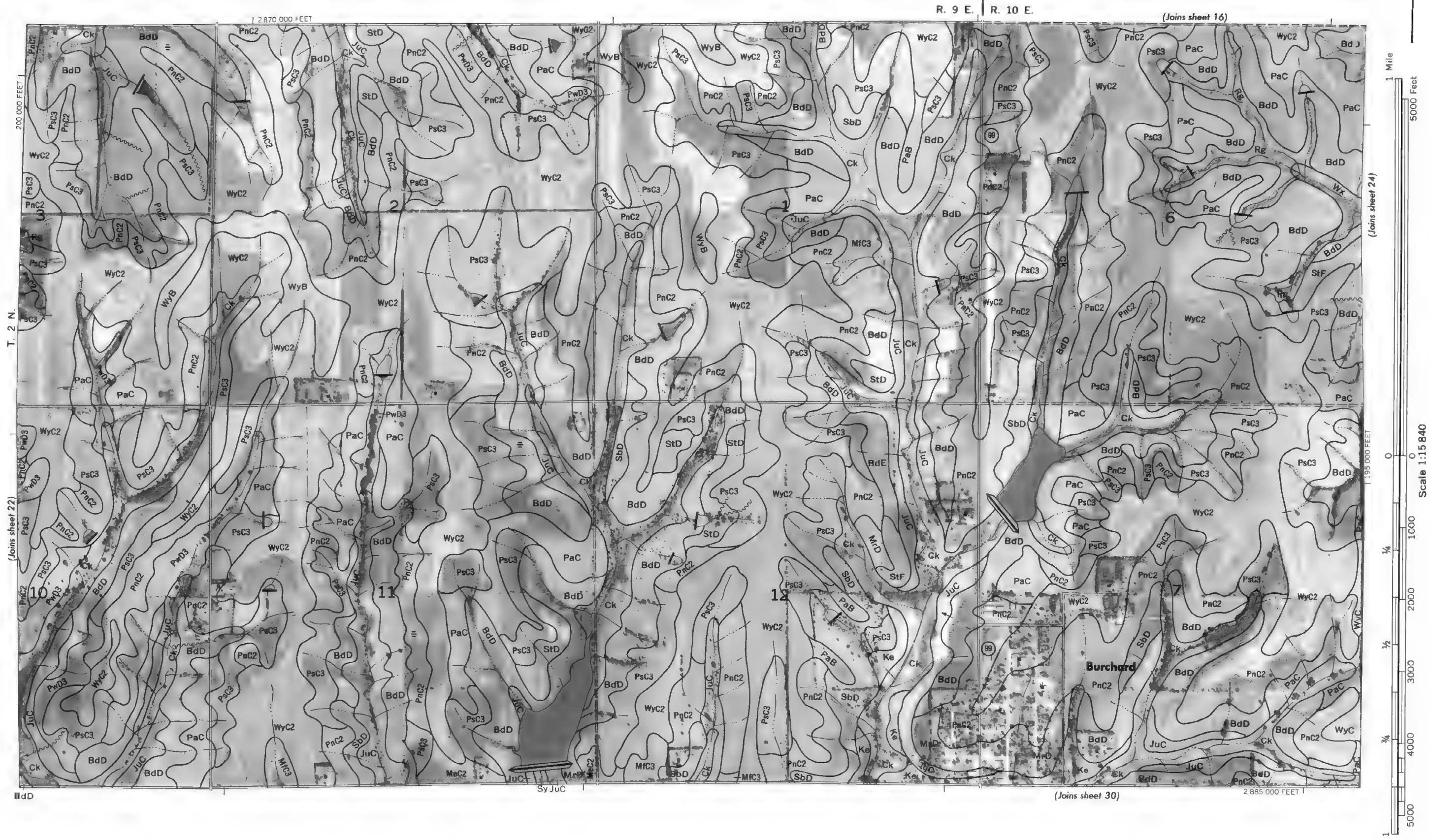
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone. Land division corners are approximately positioned on this map.

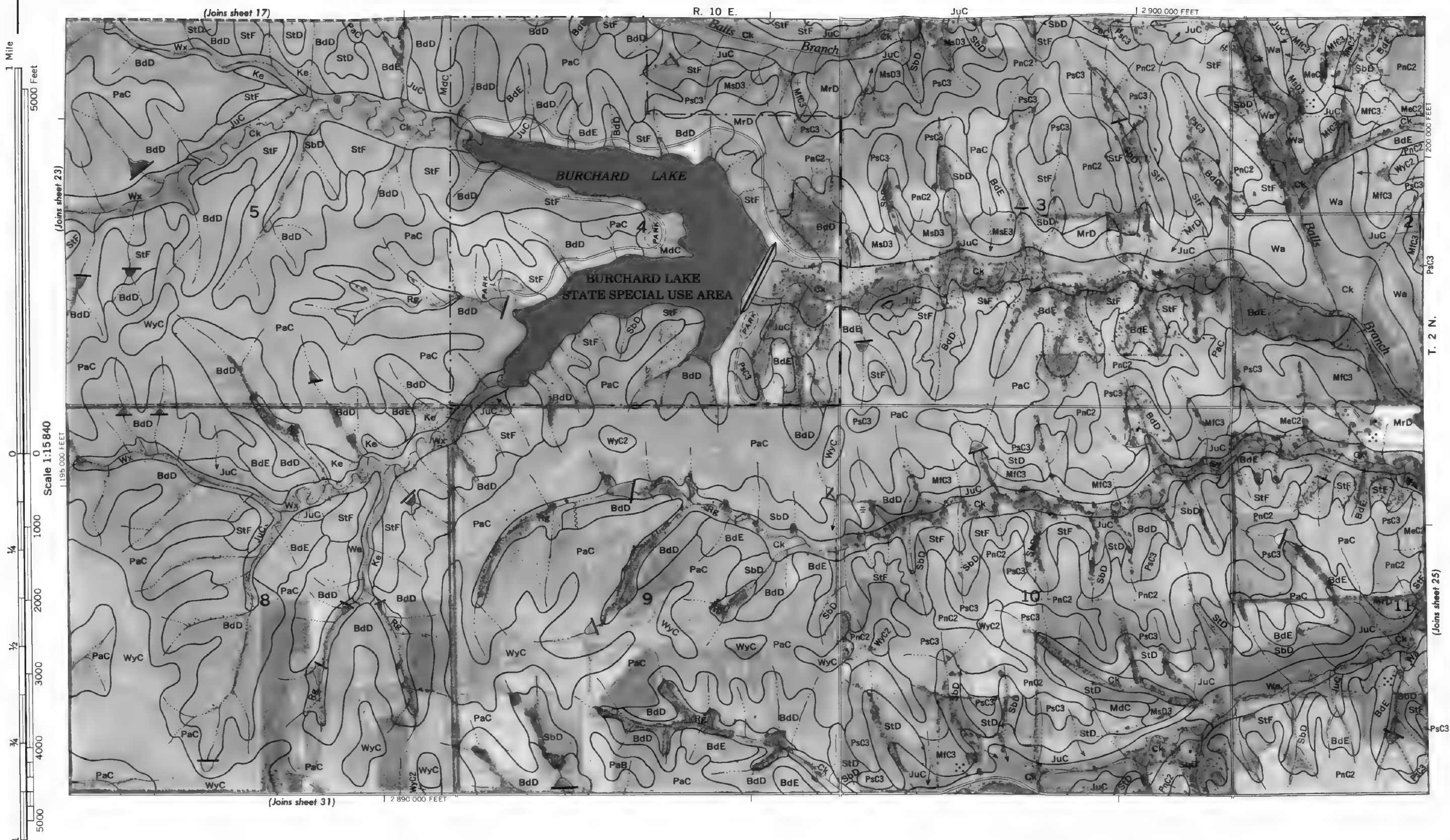




Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

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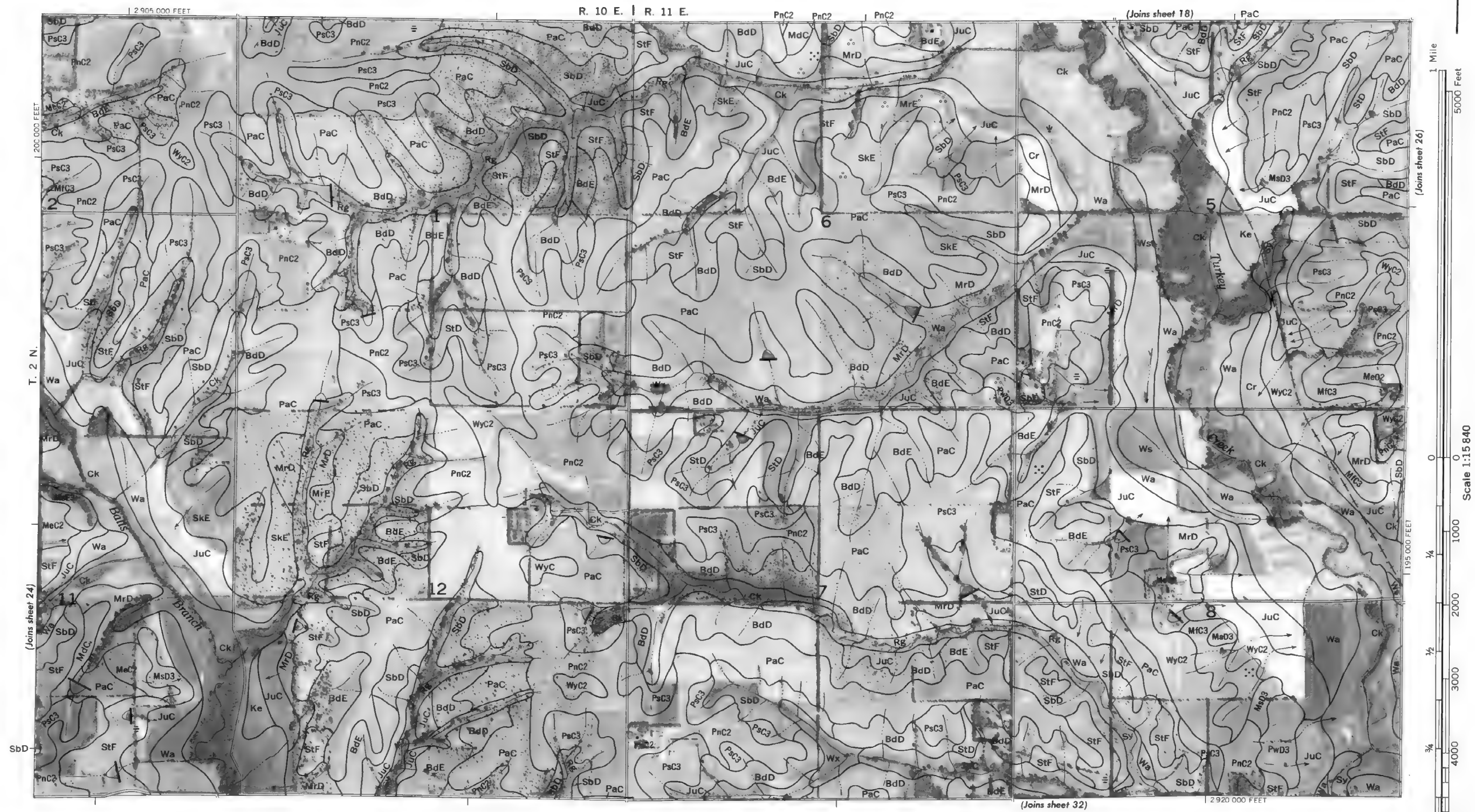
Land division corners are approximately positioned on this map.

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

PAWNEE COUNTY, NEBRASKA NO. 25

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, not UTM zone 12 and division corners are approximately positioned on this map.



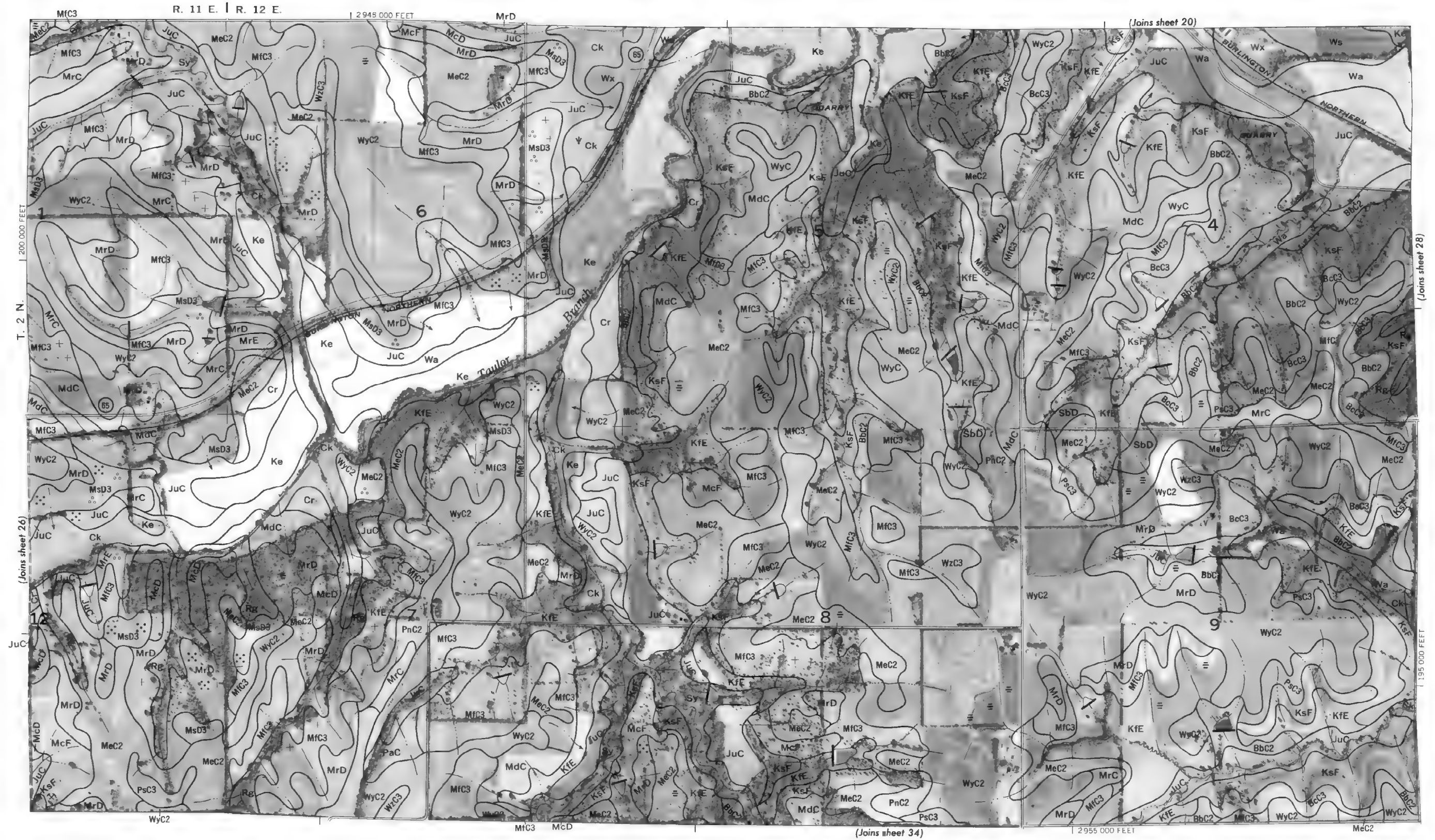


Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

PAWNEE COUNTY, NEBRASKA NO. 27

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971, aer a. photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone

Land division corners are approximately positioned on this map



(or Janss)

Scale 1:15840

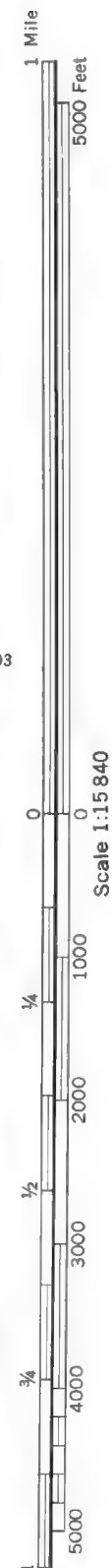
Scale 1:15840



Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.
PAWNEE COUNTY, NEBRASKA NO. 28



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
Land division corners are approximately positioned on this map.

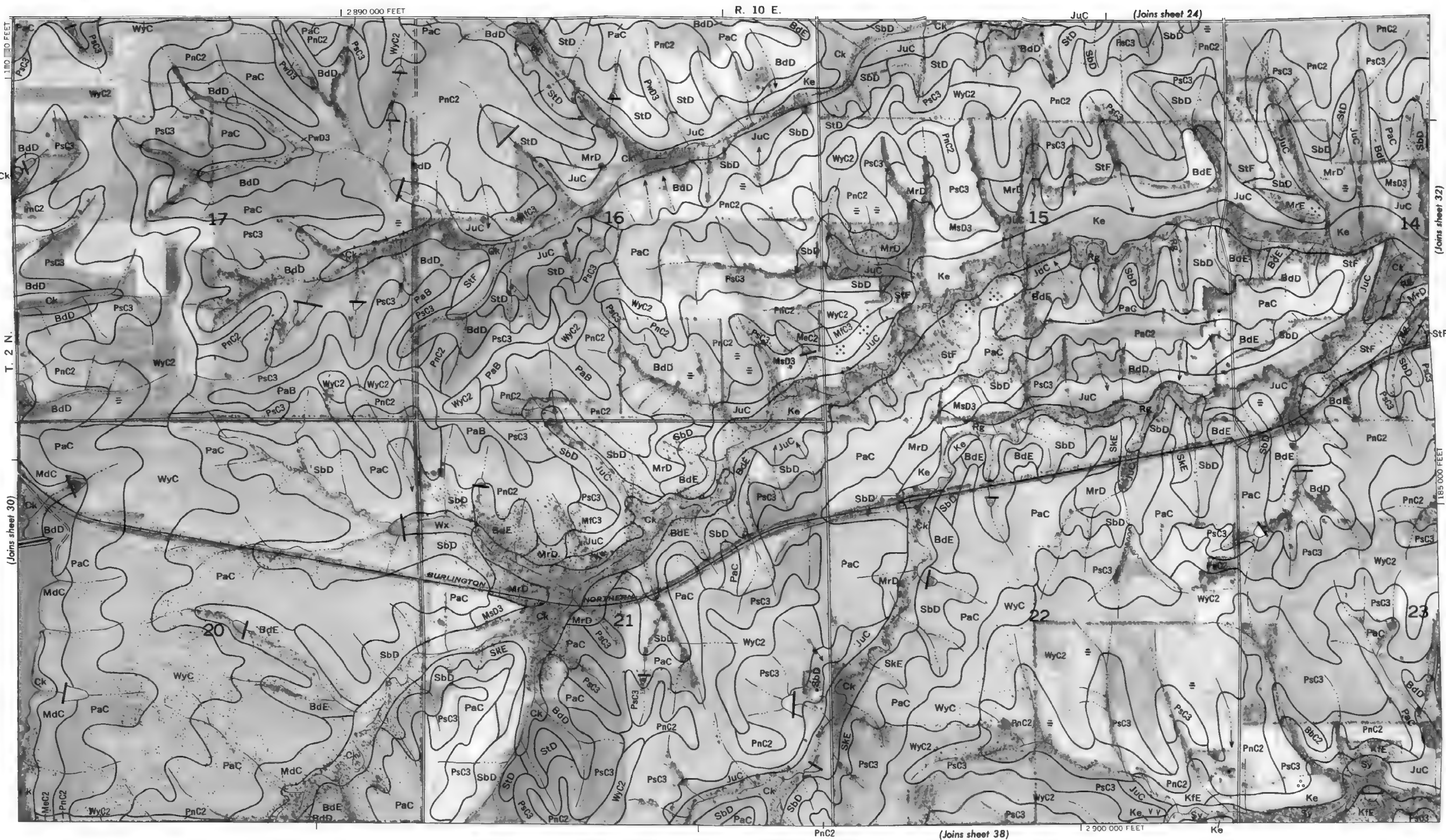




Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.

Land division corners are approximately positioned on this map.

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.



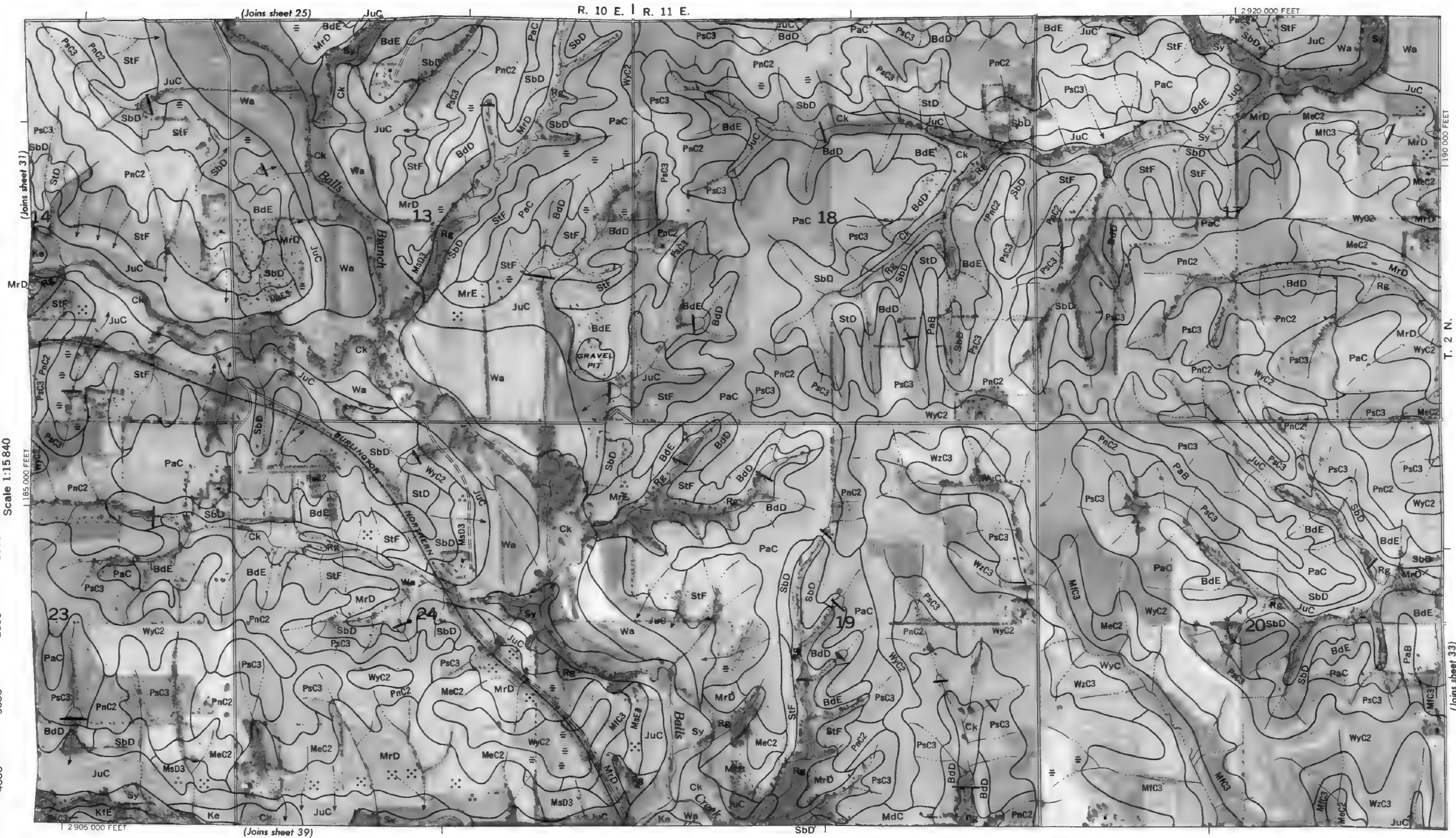
(Joins sheet 30)

(Joins sheet 32)

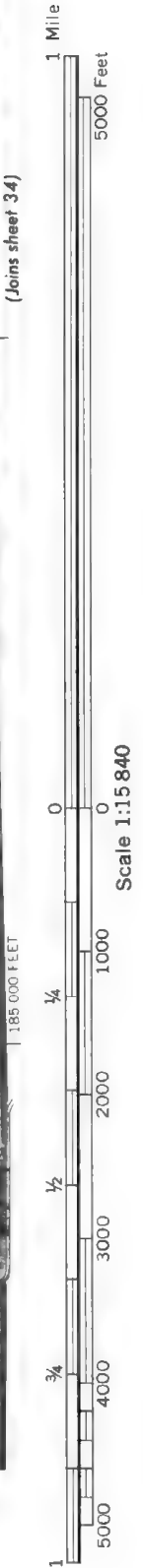
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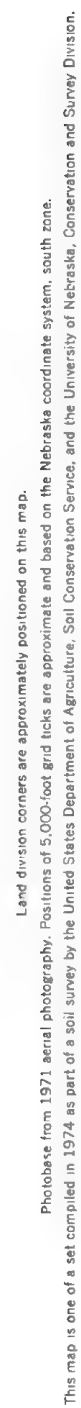


This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone. Land division corners are approximately positioned on this map.



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone. Land division corners are approximately positioned on this map.







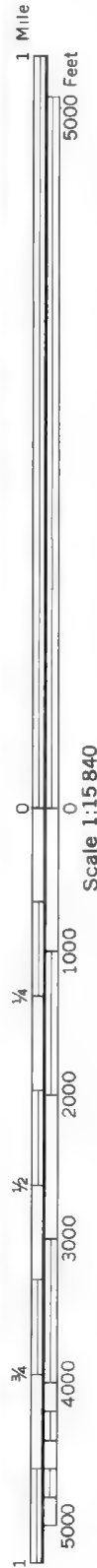
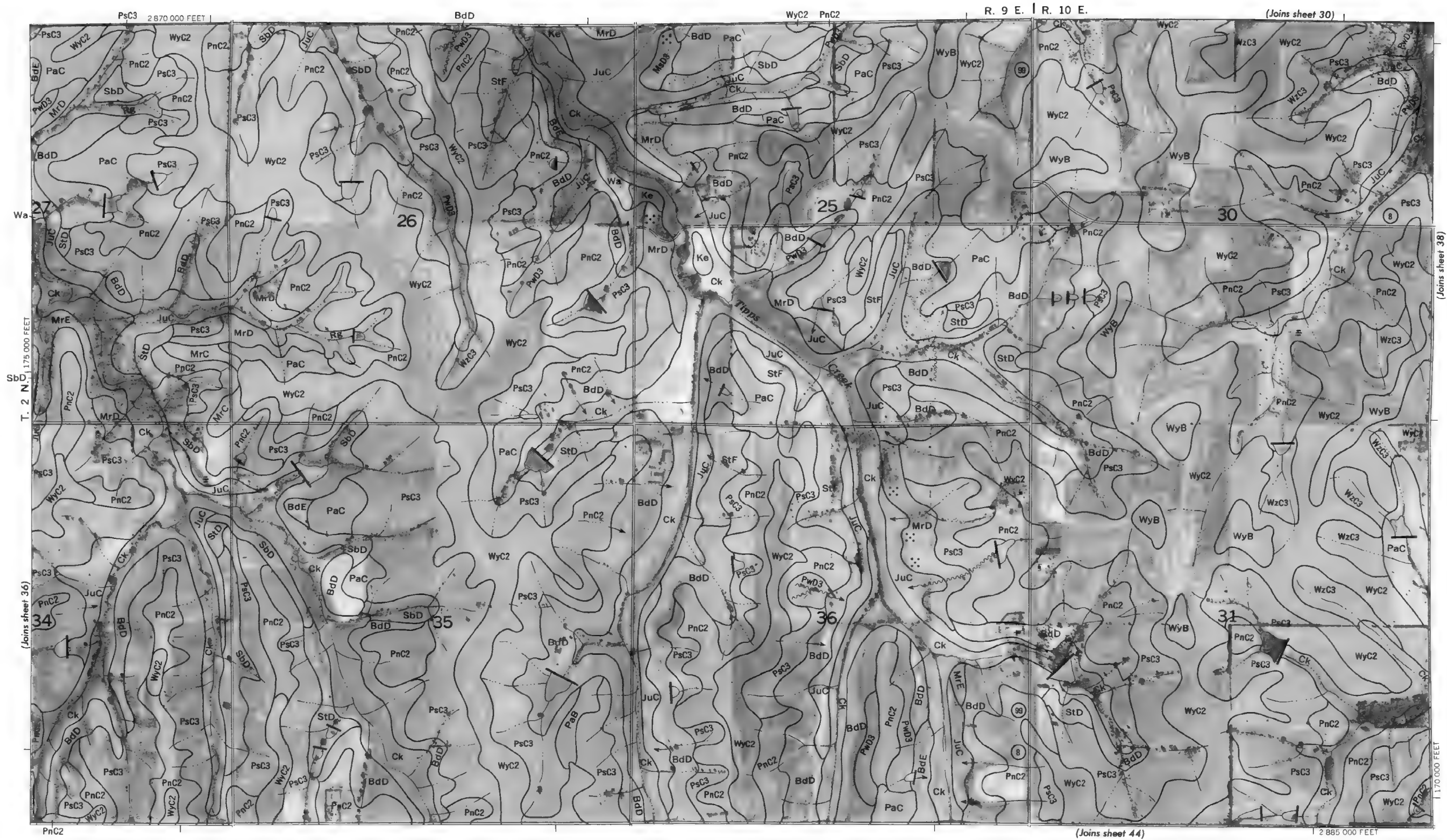
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone. Land division corners are approximately positioned on this map.



Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.
PAWNEE COUNTY, NEBRASKA NO. 36



This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone. Land division corners are approximately positioned on this map.

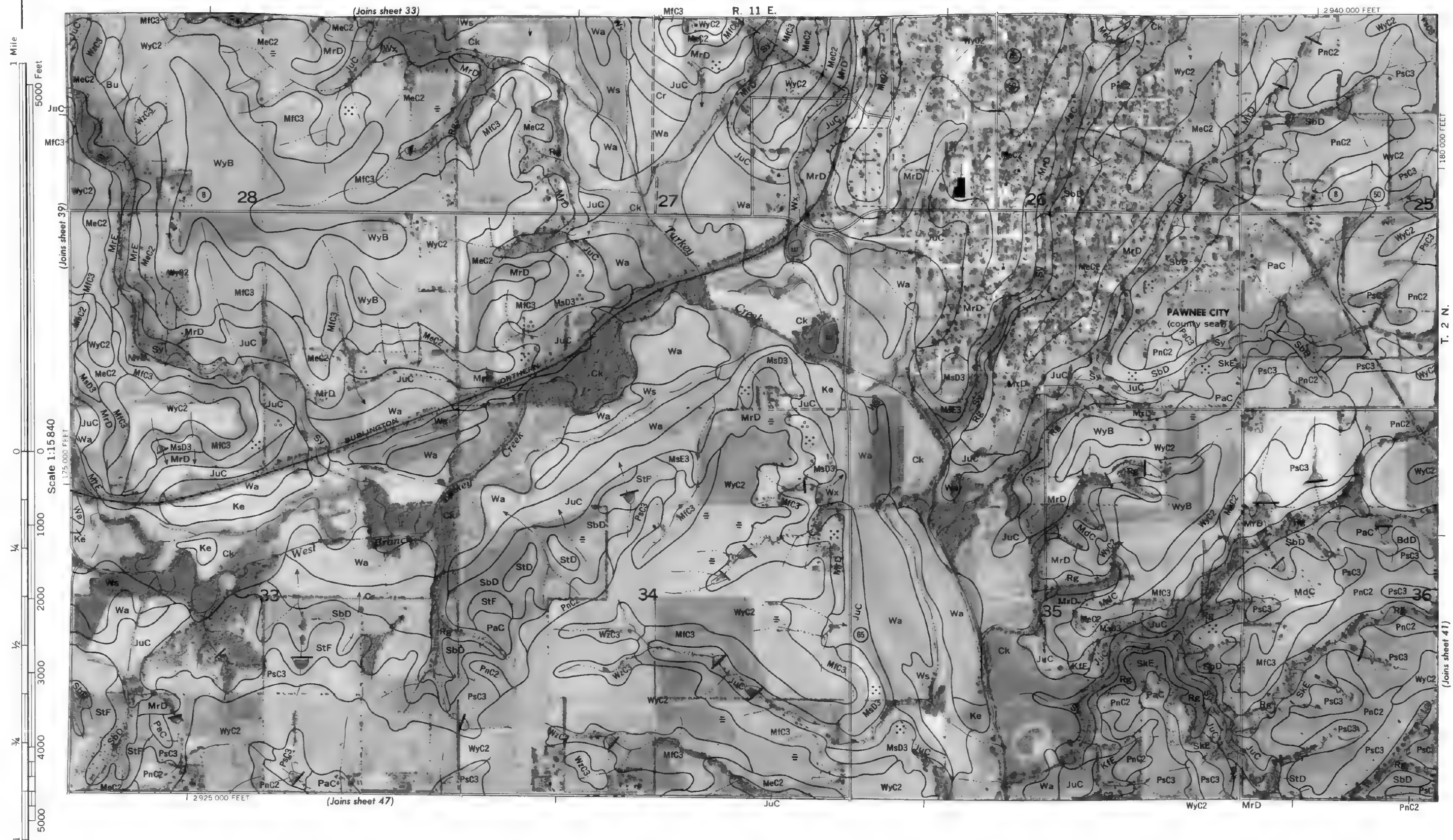




Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

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Land division corners are approximately positioned on this map

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

PAWNEE COUNTY, NEBRASKA NO. 40



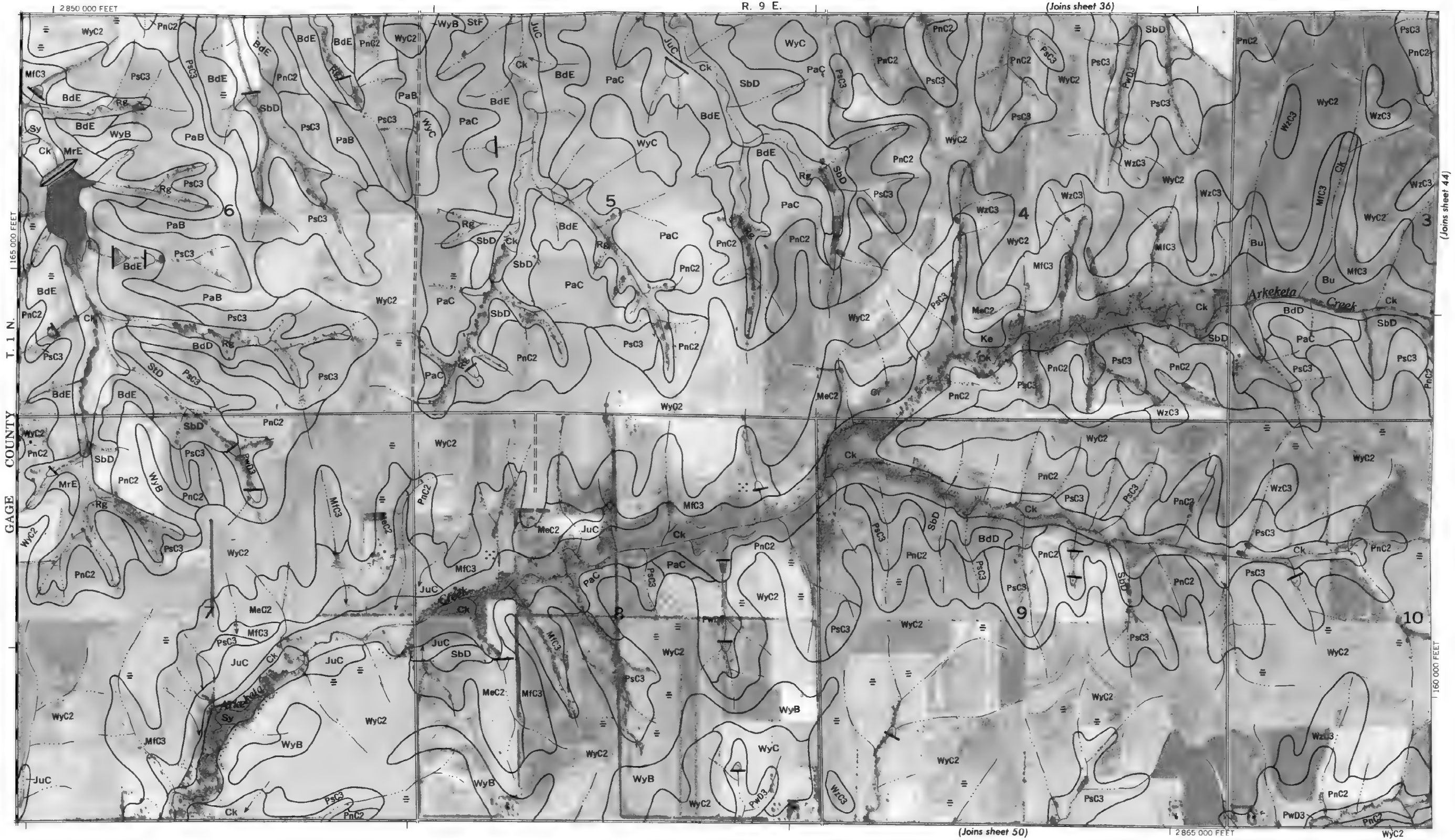
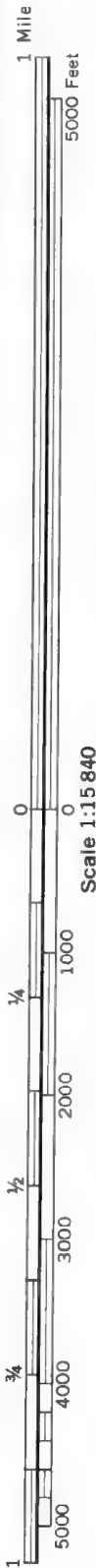
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.

Land division corners are approximately positioned on this map.





Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.



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Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

PAWNEE COUNTY, NEBRASKA NO. 45

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone. Land v. vision corners are approximately positioned on this map.

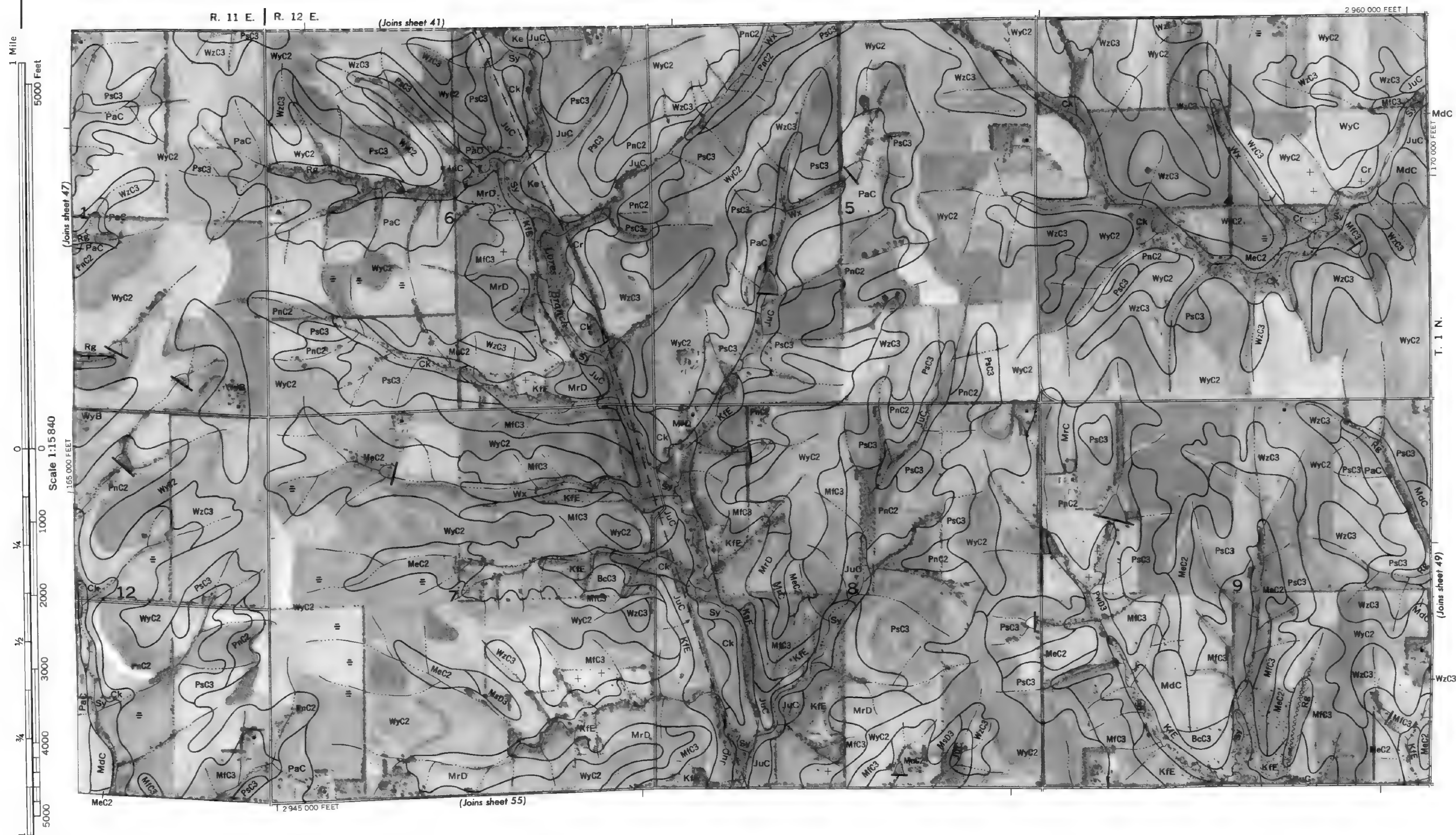


PAWNEE COUNTY, NEBRASKA NO. 47

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.

Land division corners are approximately positioned on this map.





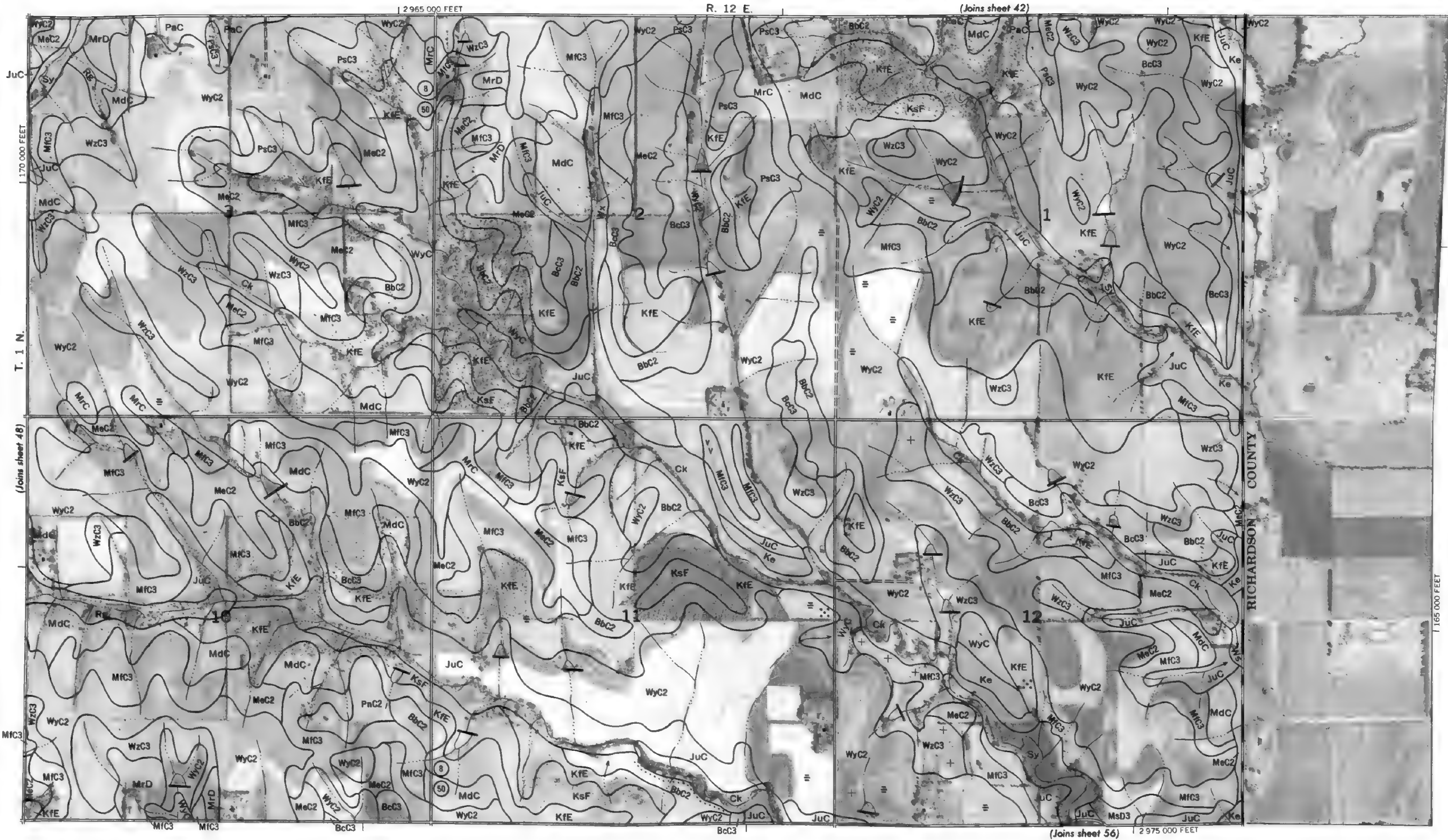
Land division corners are approximately positioned on this map

Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska. Conservation and Survey Division.

PAWNEE COUNTY, NEBRASKA NO. 48

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
Land division corners are approximately positioned on this map.





1 Mile

5000 Feet

1500 Feet

1000 Feet

500 Feet

250 Feet

125 Feet

62.5 Feet

31.25 Feet

15.6 Feet

7.8 Feet

3.9 Feet

1.9 Feet

0.9 Feet

0.4 Feet

0.2 Feet

0.1 Feet

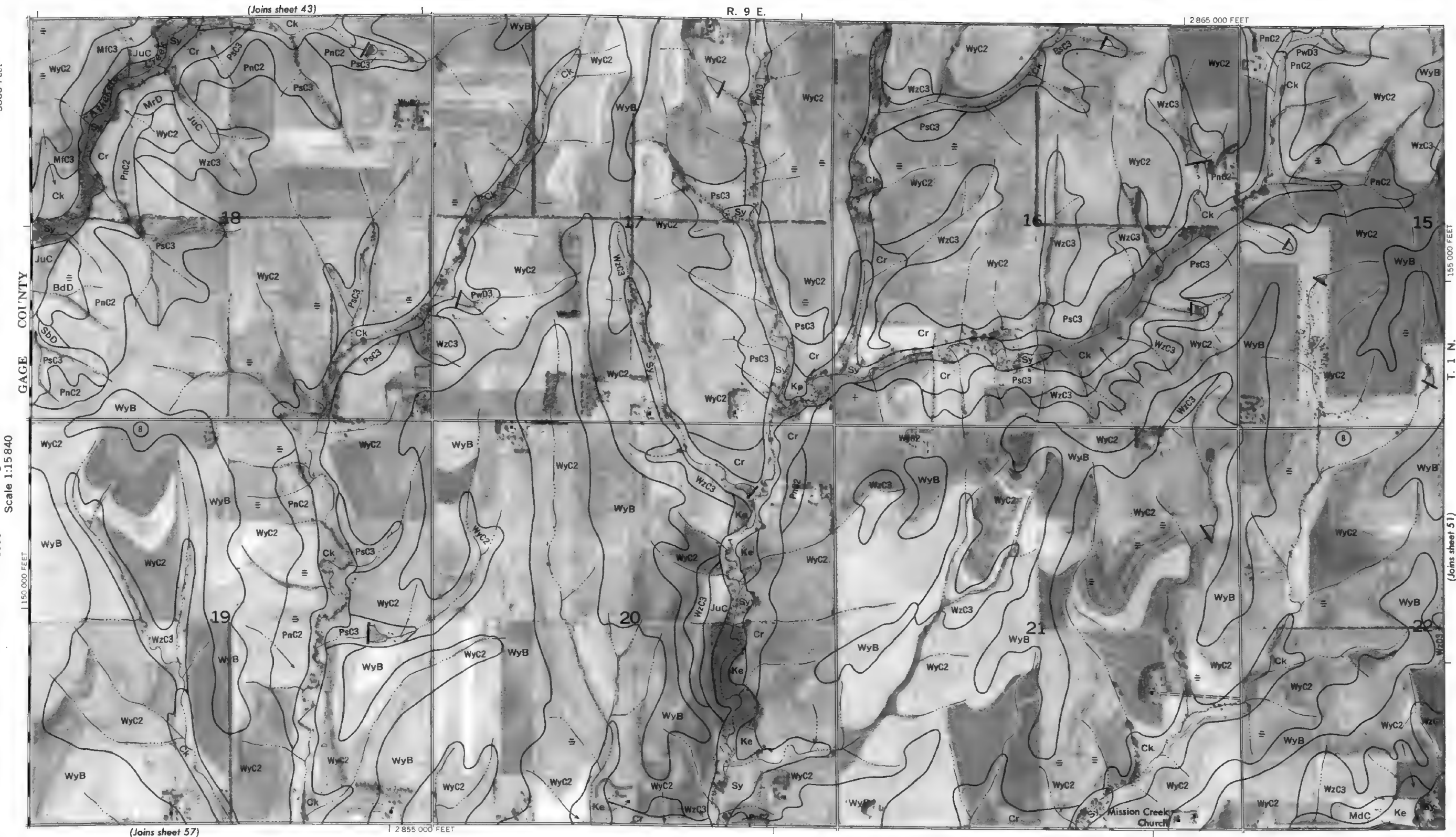
0.05 Feet

0.025 Feet

0.0125 Feet

0.006 Feet

0.003 Feet

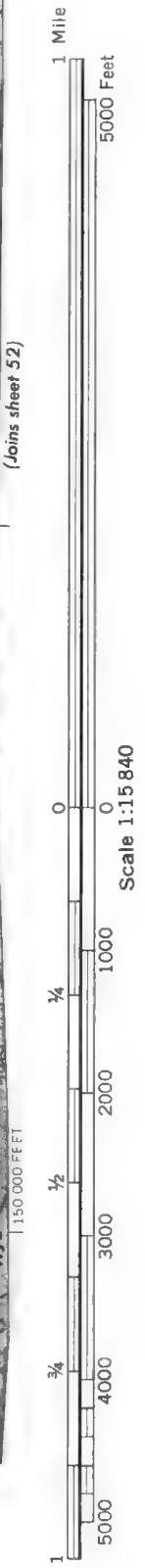


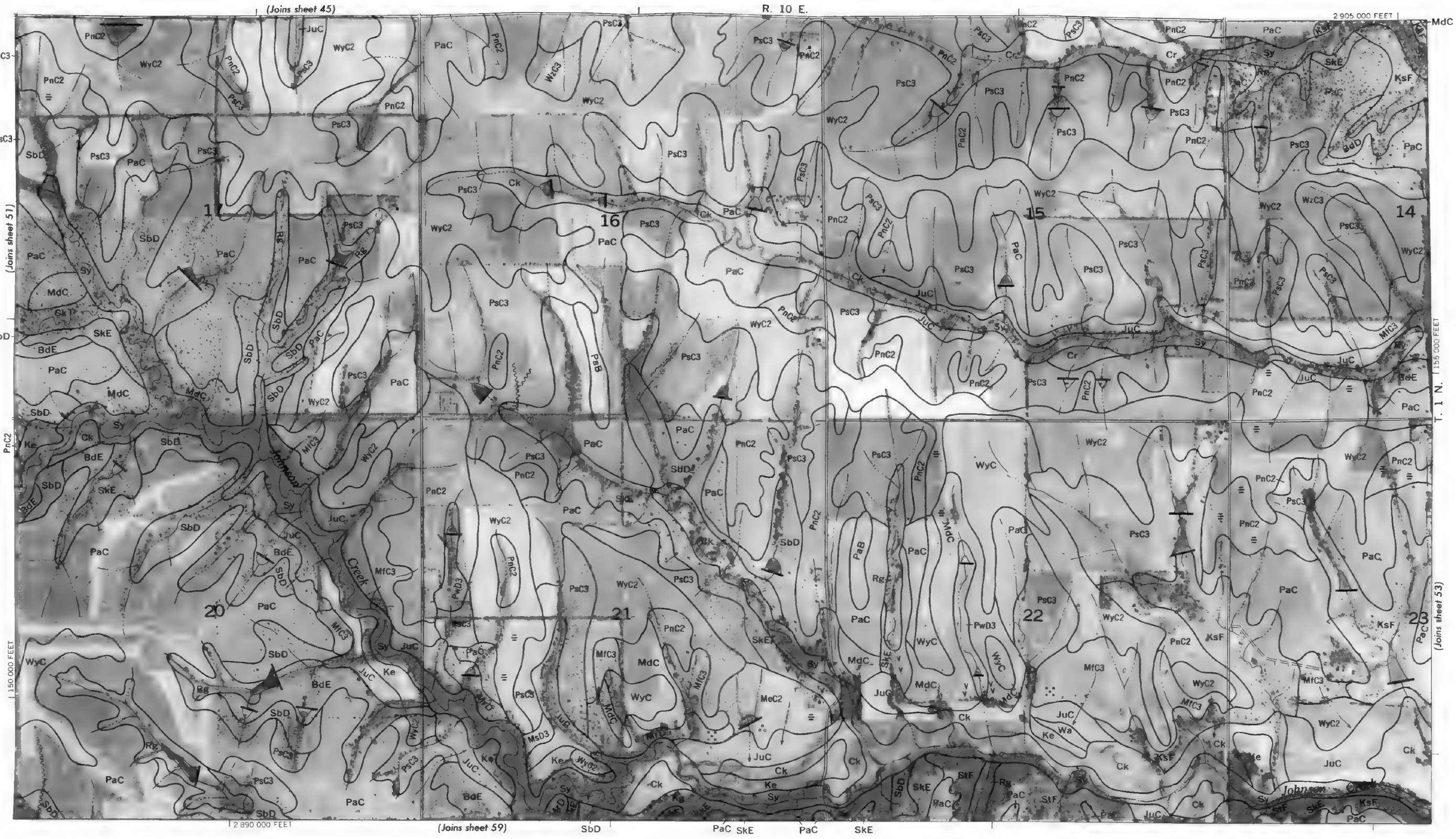
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

PAWNEE COUNTY, NEBRASKA NO. 50

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone

Land division corners are approximately positioned on this map.





Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

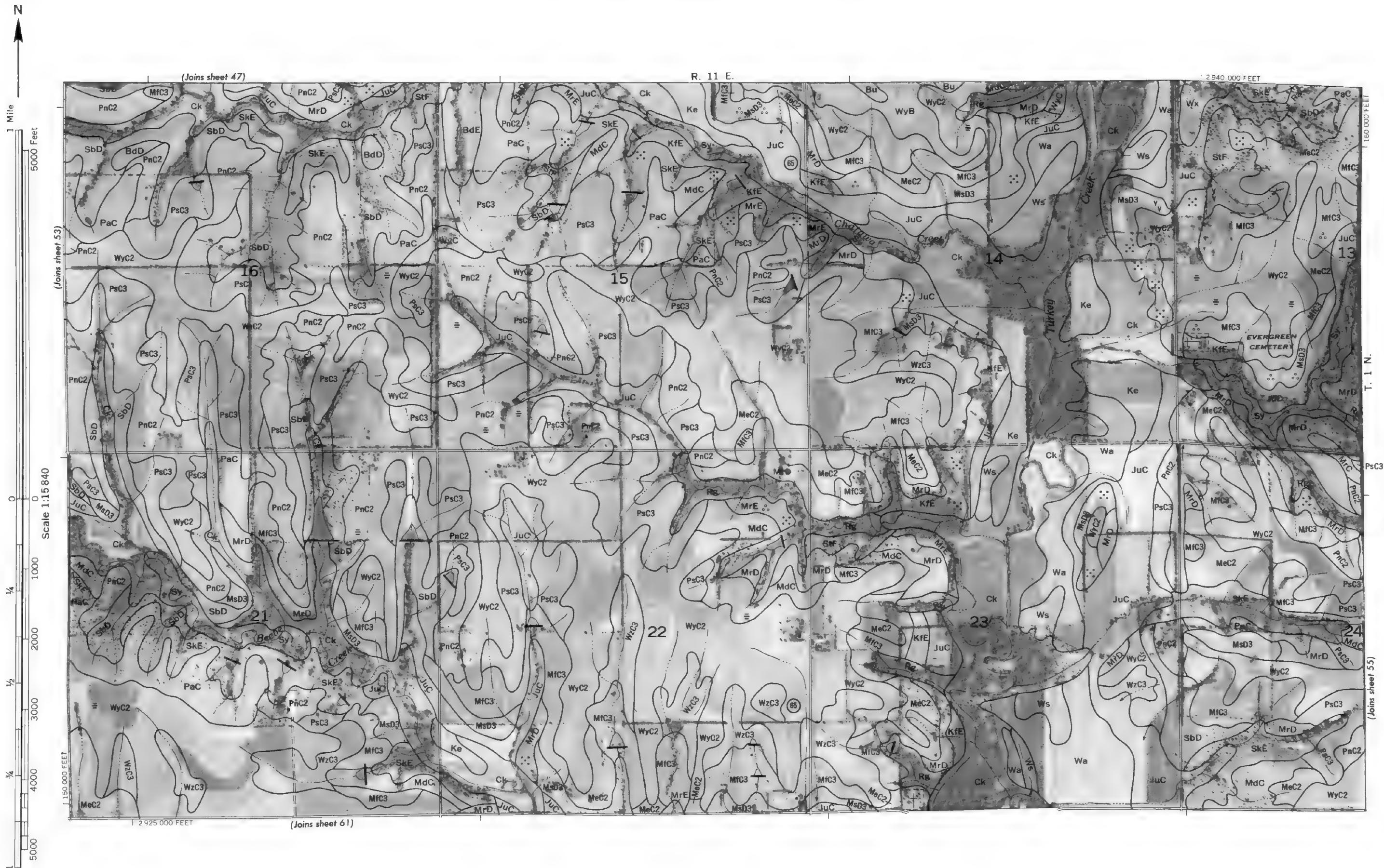
PAWNEE COUNTY, NEBRASKA NO. 53

This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.

Figure 2. The effect of the concentration of the *Agrobacterium* suspension on the transformation efficiency of *Agrobacterium* strains.

Land division corners are approximately positioned on this map





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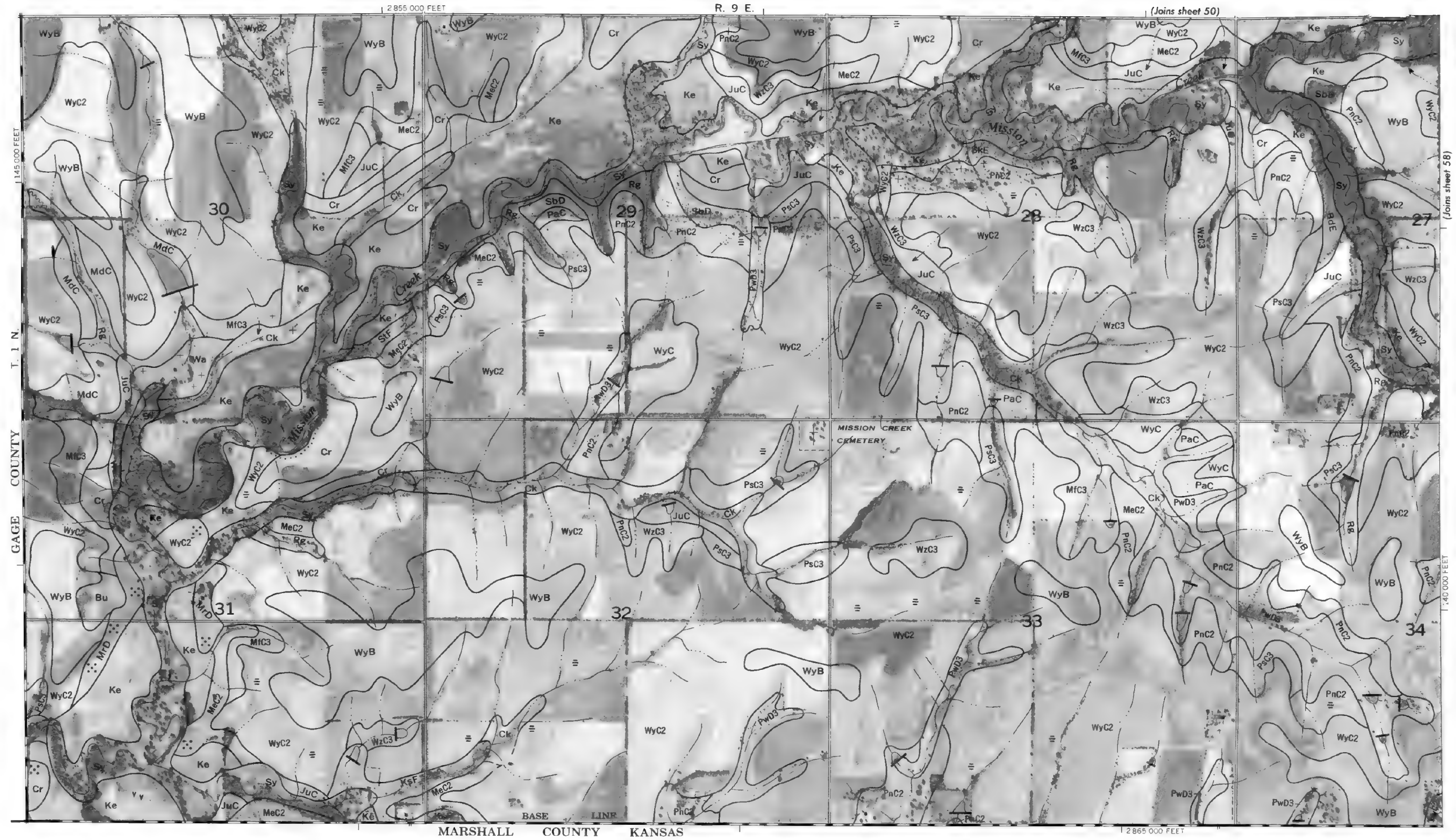
Land division corners are approximately positioned on this map



Scale 1:15840

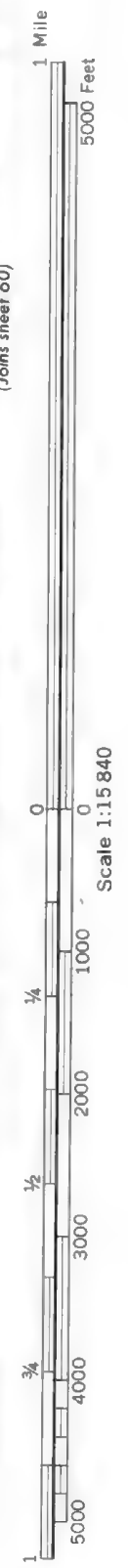
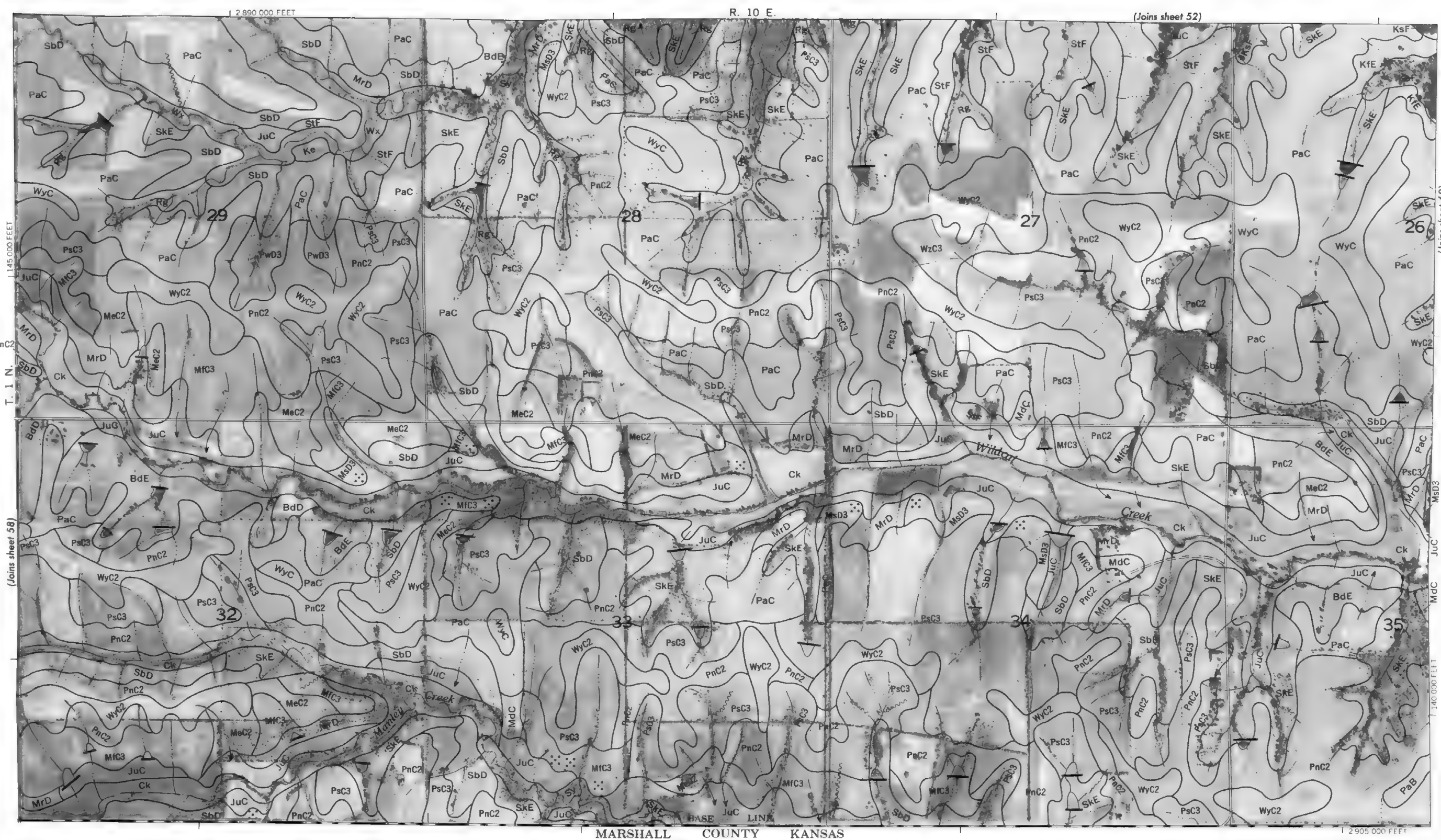
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Land division corners are approximately positioned on this map

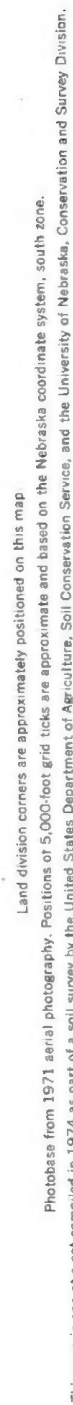




Land division corners are approximately positioned on this map.
Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone.
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division.

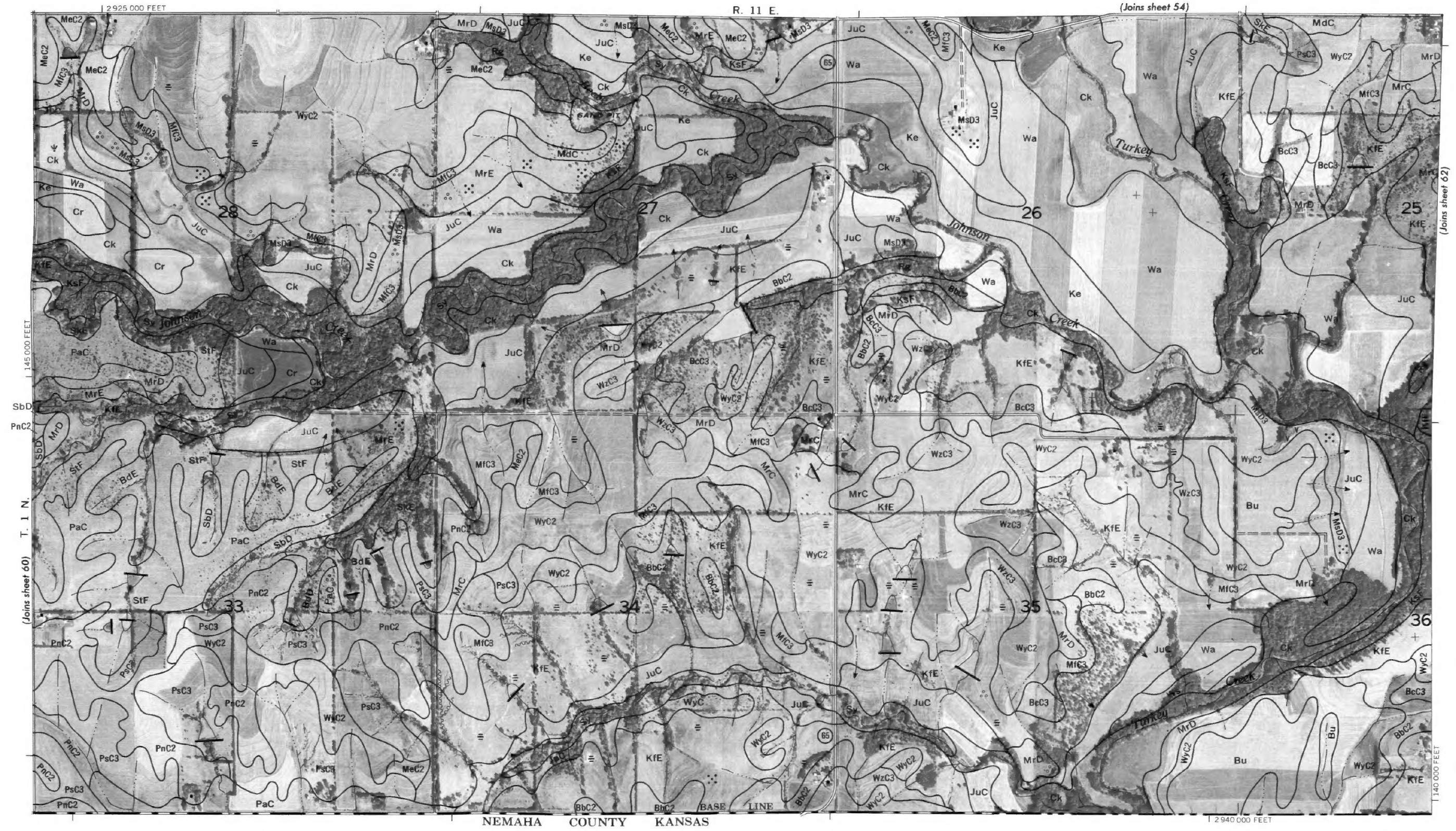


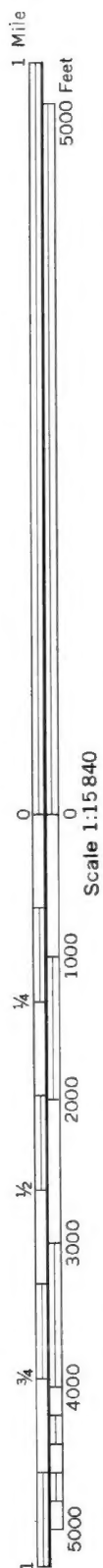
This map is one of a set compiled in 1974 as part of a soil survey by the United States Department of Agriculture, Soil Conservation Service, and the University of Nebraska, Conservation and Survey Division. Photobase from 1971 aerial photography. Positions of 5,000-foot grid ticks are approximate and based on the Nebraska coordinate system, south zone. Land division corners are approximately positioned on this map.





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PAWNEE COUNTY, NEBRASKA NO. 62

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